SCIENTIFIC AMERICAN

SUPPLEMENT No. 291

Scientific American Supplement, Vol. XII., No. 291. Scientific American, established 1845.

NEW YORK, JULY 30, 1831.

Scientific American Supplement, $5 a year. Scientific American and Supplement, $7 a year.

H.M.S. POLYPHEMUS.

THIS novel specimen of naval architecture, which is the subject of three of our illustrations, was launched June 15, 1881, at Chatham Dockyard. It is not exactly a ship, but a "torpedo ram"—that is to say, a vessel designed, with a projecting point at the bows, to pierce or run down the enemy's ships, and also to discharge explosive torpedoes for the purpose of blowing them up. The Admiralty Director of Naval Construction, Mr. Barnaby, C.B., was the designer of the Polyphemus, and the construction of it (or of her, to use the customary female personal pronoun) was begun in September, 1878, by Mr. R. P. Saunders, chief constructor at Chatham Dockyard, and Mr. Penny, senior foreman in charge. The shape of the hull is a cylinder with tapering ends, the upper side or hull deck being arched, though not so much as to present a circular midships section. Upon this hull is mounted a superstructure of iron and timber, consisting of a main deck running fore and aft, and above it a hurricane deck. At intervals along the sides of the hurricane deck will be placed six turrets—three on either side—which will carry the heaviest class of Nordenfelt guns. Protruding upward through this deck are two protected conning towers, one at each end, which form means of ingress and egress to and from the interior. There are also two ventilators and a smoke funnel. The superstructure may all be shot away without injuring the vessel herself or impairing her powers, save only as regards the Nordenfelt guns.

The steam steering apparatus is placed below, over the after boiler-room; the steering-room is in telegraphic communication with the forward conning tower. The steering apparatus can, however, be actuated from the conning tower by manual gear which is fitted therein. As the Polyphemus carries no canvas, masts are dispensed with, and beyond a flag-staff or two nothing will appear above her decks but the towers, the ventilators, and the funnel. She will be propelled by twin screws, which are carried in framings, one on each side near her stern. These screws are three-bladed, 14 ft. in diameter, from 15 ft. to 17 ft. pitch, and with a blade surface in each screw of 45 ft. She is also fitted with two rudders, which are placed under her hull near her bows, and can be lowered for use and raised again into recesses in which they are ordinarily carried. They are intended to be used for special maneuvering purposes. There is an ordinary rudder at the stern. The ram projects some 14 ft. beyond the body of the vessel, and is made hollow for the discharge of Whitehead torpedoes. The port or opening is covered by a solid steel cap, which forms the ram-point, but which, by means of a twisted sliding bar, can be easily pushed forward and turned up to allow of the discharge of the torpedo some 8 ft. below water-level, and is as easily closed afterward. Besides this, there are four other torpedo ports for the discharge of the same class of weapon, two being placed on either side of the vessel near the bows. She will also carry spar or deck torpedoes.

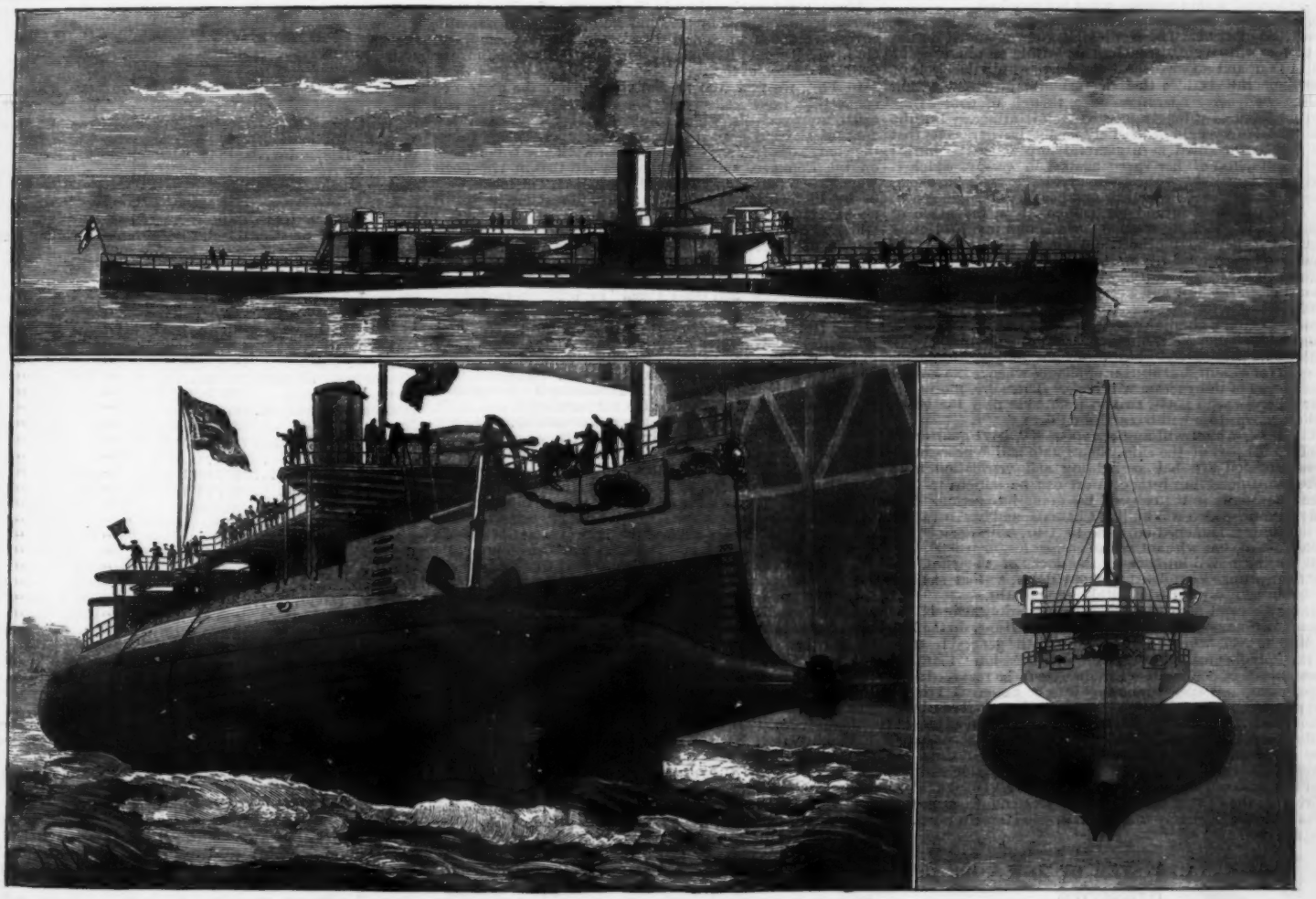
The framing of the Polyphemus is of Landore-Siemens steel, over which is a double layer of half-inch plates of the same material. Upon this, again, is superimposed a plating of Whitworth fluid compressed steel, the plates measuring 10 ft. long by 2 ft. 6 in. deep and 1 in. thick. Her outer armor consists of small plates or scales, also of Whitworth compressed steel, measuring 10 in. square by 1 in. thick, running off to ¾ in at the ends. The plates are fastened on by five screws, one at each corner, which holds three other plates, and one in the center. This plating covers her curved deck, and extends a short distance down below water level. The vessel measures 240 ft. long between perpendiculars, and has an extreme breadth of 40 ft., with a depth of hold of 18 ft. 9 in. Her immersed midship section is 635 square feet, and she draws 19 ft. 6 in. of water forward and 20 ft. 6 in. aft, her displacement load being 2640 tons. The hull is divided into a number of water-tight compartments.

The engines, which are by Messrs. Humphrys, Tennant & Co., are of the compound, horizontal, single piston-rod type, having four cylinders, the two high-pressure being 38 inches in diameter, and the two low-pressure 64 inches in diameter, with a 39-inch stroke. Her indicated horse power is 5,500, and her estimated maximum speed seventeen knots. Steam will be supplied from ten boilers of the locomotive type, at a working pressure of 120 lb. per square inch, they having been tested to double that pressure—viz., 240 lb per square inch. The air-compressing machinery for the torpedoes and the steam steering apparatus are by Mr. Peter Brotherhood. The weight of the machinery, inclusive of the water in the boilers and ten tons of spare gear, is four hundred and ninety tons.

The ceremony of the launch was attended by Admiral Sir George Sartorius, Admiral Sir Houston Stewart, the Secretary to the Admiralty, Mr. G. O. Trevelyan, the Admiral Superintendent of Chatham Dockyard, and other official persons, with several Members of Parliament. After the usual prayers and benediction, pronounced by the chaplain, with the quaint formality of "christening," by dashing a bottle of wine against the bows, Mrs. G. O. Trevelyan handled a lever which released the "dogshores," and allowed the Polyphemus to glide down into the river Medway. The vessel had all her engines on board. She has been taken into dock, to be made ready for her steaming trials.—*Illustrated London News.*

THE POLYPHEMUS.

THE completion of the Polyphemus gives a novel and apparently a formidable addition to the British Navy, but one that must be regarded as largely experimental until it is submitted to the test of actual warfare. The appearance of the hull suggests that of the Winans cigar ship, but this effect is concealed by the false works and turrets. The vessel is 240 ft. long, and 40 ft. in extreme breadth; the draught of water being 19 ft. 6 in. forward, and 20 ft. 6 in. aft; the displacement is 2,640 tons. She is built throughout of steel, and is framed with transverse brackets and continuous longitudinals, and with a double bottom the whole length of the ship. The lower part is subdivided into a large number of cellular spaces, while the hold is divided by a longitudinal bulkhead and numerous transverse bulkheads, and the engine and boilers are contained in six water-tight compartments. Over the framing of the ship is placed a double plating of Landore-Siemens steel, each plate being half inch thick, and upon these is a thickness of Whitworth's fluid compressed steel in plates 10 ft. long, 2 ft. 6 in. deep, and 1 in. thick. The armor plates which cover the whole of the curved deck and sides below the water line are peculiarly arranged. They are also of Whitworth compressed steel, and are made in plates or scales 10 in. square and 1 in. thick. These scales overlap each other in such a way that the securing coned steel plugs, which are placed one in each corner, hold three adjacent plates, there being only one central plug. Forming a part of the rigid structure of the vessel are six steel-clad revolving turrets, three on each side, which will be armed with the heaviest class of Nordenfelt guns. At each end of the ship also there is an armored conning and



LAUNCH AT CHATHAM DOCKYARD.

BOW VIEW, SHOWING HULL BELOW WATER LINE.

H.M.S. POLYPHEMUS, NEW TORPEDO RAM.

steering tower, entered from the interior of the vessel. There are also two armor-plated ventilating shafts and a smoke-stack.

The superstructure reared upon the hull gives to the Polyphemus something of a ship-shape appearance. It consists of a forecastle rising 9 ft. out of the water, a main deck, and a flying deck carrying boats and two large life rafts; this superstructure is of course quite independent of the ship's framing, and may be all shot away without affecting her safety. A special feature in the Polyphemus is the absence of keel, a recess or groove 3 ft. 6 in. deep, 2 ft. 6 in. wide at the bottom, and 2 ft. at the top, being formed along the whole length in the position usually occupied by the keel. This groove is divided into sections by transverse partitions placed across it, each section being large enough to receive a length of cast iron 10 ft. long and weighing about 50 tons. At one end each of these blocks is hooked on to the partition in the groove, and at the other end it is held by a cam attachment operated from the interior of the ship, and which can be instantaneously released, and the block detached.

The object of this peculiar arrangement is to enable the vessel to float with a lighter draught should she be damaged in action, or should any other necessity arise for such a measure, a difference of 12 in. or 14 in. being possible if all the 300 tons of ballast thus carried is cut loose. Whether this device will prove satisfactory remains to be tested.

The engines of the Polyphemus were constructed by Messrs. Humphrys, Tennant & Co.; they are horizontal single piston rod compounds with high pressure cylinders 38 in. in diameter and low-pressure cylinders 64 in. in diameter, the stroke being 39 in. They are supplied from ten boilers of the locomotive type, with a working pressure of 120 lb. per square inch. The engines have indicated 5,500 horse power, and the estimated speed to be got with them is 17 knots. She will be propelled by three bladed twin screws 14 ft. in diameter, and from 15 ft. to 17 ft. pitch, and for special maneuvering two bow rudders are provided which can be housed within recesses when not required.

A part of the armament of this curious vessel has been already referred to. The Nordenfelt guns mounted in the six turrets will be able to inclose her within an almost solid veil of lead, and no small boat could live within the circle of their fire. But besides this they should be useful within limits for offensive operations also, though of course they would be useless at long ranges or against armor. But the real offensive strength of the Polyphemus lies in the fact that she may be regarded as a gigantic torpedo to be hurled bodily at the top of her speed against an enemy, which if fairly struck would have no alternative but to go down, and as she can be very easily handled, and possesses a high speed, she should prove a formidable antagonist in this mode of fighting. The striking weapon consists of a ram projecting about 13 ft. beyond the hull, and placed so far below the water level as to render it most effective against the unprotected hull of an adversary. This ram, which is strongly framed on to the hull and armor plated, is terminated by a solid steel spur forming a cap which, when desired, can be turned up, and a circular opening within the ram exposed. From this opening the Whitehead torpedo can be discharged, so that this part of the ship forms not only a formidable weapon for assault, but also the appliance whence the smaller implements of destruction will issue. There are, moreover, four other torpedo ports, two on each side near the bows, and spar torpedoes will be carried on deck.

The crew, which will number about 130, have quarters in the forward part of the ship, the captain and officers being accommodated aft, but as lighting and ventilation must alike be artificial, but little comfort can be anticipated for them, especially in the case of her going into action. The Polyphemus, which was built at Chatham, and has cost about £150,000, was launched on June 15, 1881, with engines and boilers fitted, but without armament, stores, or ballast. She will now be moved into one of the docks of the yard, and her final fittings completed without delay, so that she will probably be ready for trial within two months.

It may be well here to recall some remarks made in the House of Commons, by the late Mr. Ward Hunt, on the 12th of March, 1877, when he was describing the general features of the Polyphemus. He said on that occasion "that this vessel must, of course, to a certain extent, be regarded as an experiment, and even supposing it to be a success, I could not propose it to the House as being likely to supersede all other kinds of fighting ships, but only as a useful adjunct to a fleet in case of war. Probably it would not be desirable that she should be kept at sea for a long period of time, but I venture to think she will prove a very formidable weapon, and if she should be a success, she may be regarded as a sort of rival to those monster ships with tremendous armor we hear spoken of as likely to be built in some foreign ports."—*Engineering.*

THE CANAL SYSTEM OF NEW YORK.*

INTRODUCTION.

THE importance of the water ways of New York to inland transportation, as connecting the West with the East and with Europe, makes a concise study of their present state and their future interesting; it is also a duty the present generation owes the past and the future, to put on record, as occasion serves, such historical notices of the engineers of the past and their works as may be within reach.

With this view the following paper has been prepared for the society as a brief contribution to the history of the New York Canals, a record of their condition, and an index of some desirable improvements.

This subject is discussed in the following order: Canal Projectors, Engineering, Original Engineer Corps, Construction and Maintenance, Water Supply, Defects and Remedies, Steam Propulsion, Business, Transportation Cost, Buffalo Charges, Proposed Improvements.

Respectfully submitted,

SAMUEL MCELROY.

Office of McElroy & Son, Civil Engineers,
Brooklyn, January, 1881.

CANAL PROJECTORS.

Though the use of water transportation by natural and artificial routes belongs to the early age of the profession, its local and earlier application in this country is due to men of exceptional genius, whose services should be properly recognized.

During the years 1750 to 1753, a Virginian surveyor, not yet in his majority, was engaged as a member of a field party in surveys and explorations among the Alleghany Mountains. Of good family, carefully educated, of splendid physique, an enthusiast in work which is itself a fascination, affable and dignified in manner, endowed with the highest personal and moral courage, born to command, and therefore deferential to the authority and rights of others, prompt to decide, fertile in resource, calm in reverses, a keen judge of character and a close student of the future, first in the rank of patriots, of statesmen, and of military engineers, with these characteristics of professional dignity, his personal history also shows that we may claim George Washington as first in our own ranks.

His first diplomatic mission to Fort Duquesne included engineering duties, and was thoroughly performed. It put on record not only the condition and purposes of the French Army on the Ohio, but the character of the intervening country and its Indian inhabitants; a knowledge which gave the young officer under Braddock's command the opportunity for which he was so highly commended, and made him familiar with the feasible lines of movement.

In 1770, '72, and '74, Washington was engaged, at no small personal risk and expense, in exploring the lines of communication between the rivers and lakes of the West and the seaboard, and the productive character of that region, and emigration was largely influenced by his reports of 1770. Routes were examined by him between Detroit and Richmond, Washington, Philadelphia, and Albany, and in some cases field parties were employed at his expense.

In 1784, as part of this study of Virginia, Maryland, Pennsylvania, New York, and the West, he rode up the Hudson Valley to Crown Point on Lake Champlain, followed the Mohawk to Lake Oneida, examined the water communication between Lake Ontario and the Hudson, and between the Mohawk and the head waters of the Susquehanna at Otsego Lake, with its outlet in Chesapeake Bay. It was a personal survey of what, in his letter to the Marquis of Castelleaux, he calls "the vast inland navigation of the United States," and it was a continuation of the plans of communication partially presented to Governor Dinwiddie in 1753.

These early explorations in the interests of colonial commerce, were followed by personal and public application to governors and representative bodies in Virginia and Maryland, which would have resulted in practical works, but for the intervention of the Revolution.

In 1784, we find him specially engaged in the project of connecting the Potomac and the Ohio River, by river and canal improvements, which resulted in his election as President of the "Potomac Company," May 17, 1785. Under the charge of Mr. James Rumsey, the work was commenced on the Potomac, and so far progressed that in 1788 boats were locked past the Potomac Great Falls. The locks were 80 by 16 feet, built in a group of five to reach a height of about 77½ feet, with a canal about 4,500 feet long, 35 feet wide, with 4 feet depth. In the Washington aqueduct arbitration of 1862, I had occasion to make a survey of this work, still in a good state of preservation, and showing a high degree of skill in location and construction. Practically the "Chesapeake and Ohio Canal" in 1823 superseded this improvement.

The Dutch and English settlers of New York were familiar with the advantages of their home canals, and the desire to improve trade and to checkmate the rivalry of the French colonies on the Mississippi and the St. Lawrence, was shared by the merchants of the Hudson and the seaboard, with Washington in Virginia; but the population was small, capital wanting, and the distances formidable. The tendency of commerce was therefore to follow natural water ways in their valleys, and to make them the pioneers of future works. The canal history shows that they developed from incomplete works, and the upper Hudson from Champlain and the Mohawk from Ontario favored this primitive method.

In 1768, Gov. Moore advised the improvement of the Mohawk at Canajoharie; in 1788, Elkanah Watson urged the Wood Creek improvement to Ontario via Oneida Lake; in 1791, commissioners were appointed to make surveys for this plan from Albany. Boats carrying 1½ to 2 tons then ascended the Mohawk from Schenectady, made a portage of two miles to Wood Creek, at Rome, sailed thence by the Oneida Lake and Oswego River, and ascended the Seneca River to Seneca and Cayuga Lake, in a trip of 21 days, returning with five tons in eight days; they also descended the Oswego to Lake Ontario, using the Niagara portage to Lake Erie.

January 3, 1792, the favorable report of Commissioners Elkanah Watson, Gen. Philip Schuyler, and G. Banyer, with an estimate for locks, etc., of $200,000, led to the immediate charter of "The Northern and Western Inland Navigation Company," to improve the Hudson to Lake Champlain, and the Mohawk to Seneca and Ontario. In 1796 boats of 16 tons passed from Schenectady to Seneca Falls.

The practical commencement of the Erie Canal grew, in time, from this improvement. It is due to a few gentlemen of social and political prominence who, by mutual combination, in the earlier part of the century, pressed this enterprise to a successful conclusion, against bitter opposition. These were men like Gen. Philip Schuyler, Stephen Van Rensselaer, Surveyor General Simeon De Witt, Governor Morris, Elkanah Watson, and DeWitt Clinton.

DeWitt Clinton assumed the leadership and identified his political life with the canal project. In 1801, '2, and '3, practicing as a lawyer in New York city, and residing in Maspeth, Queens county, he strongly urged the construction of a canal from Flushing Bay to the Wallabout, in Brooklyn, which would have avoided the Hell-Gate navigation, and largely benefited Brooklyn and New York. Member of Assembly from New York in 1797; Senate in 1798; Mayor of the city from 1803 to 1815, except three years; Lieutenant-Governor from 1811 to 1813; Governor from 1816 to 1822; author of the Canal Memorial and Commissioner in 1815; delegate to throw the first spadefull in 1817; first among the through passengers of 1825, and yet removed as Commissioner in 1824, by opponents, who had learned the value of canals—this statesman, without question, ranks all others in New York as the promotor of the canal system.

CANAL ENGINEERING.

In professional foresight, advocacy and counsel, from his social and official position, Surveyor General Simeon De Witt occupied a prominent rank, and without direct field work his services were undoubtedly of great value. At that time, while compass surveying was well understood, leveling was a mystery, and construction very little practiced as now known.

For the Wood Creek Canal and locks, and other projected work of the "Inland" Company, an English engineer was brought from the Liverpool and Manchester Canal—William Weston, C. E.—who acted as consulting engineer from 1796 to 1808, planned a system of locks for Cohoes Falls, and in 1799 made a report on the water supply of New York City. Benjamin Wright was his assistant, and thus acquired an experience which made him virtually the chief engineer of the subsequent canal work. The superintendent of the stone locks at Wood Creek was James McElroy, of Albany, builder of the Capitol, the Waterford bridge, and other works, and of northern lake fortifications. As part of this system of transportation, legislation was made in 1798 for a canal at Niagara Falls, to connect Ontario and Erie, but the work was not commenced.

In 1803 the plan of a canal from Lake Erie to the Hudson was discussed by Mr. DeWitt with Gov. Morris, and in 1808 he selected George Geddes, an accomplished surveyor, to locate a canal from Oneida Lake to Ontario, and at Niagara Falls; and also an interior line from Oneida Lake to the Genesee River, Tonawanda Creek, and the Niagara, near Lake Erie. River, creek, and lake navigation is still retained in this plan, and the war of 1812 found parties in warm discussion between the Ontario line to Niagara and an internal canal line.

The practical beginning of the canal was in 1816, when Commissioners Clinton, Van Rensselaer, Young, Ellicott, and Holleys, appointed by act of April 17, at a meeting held May 17, selected four engineers for the Erie and Champlain Canals. The western division of the Erie was assigned to James Geddes, the middle to Benjamin Wright, the eastern to Charles C. Broadhead, the Champlain to Lewis Gavin, and explorations between Buffalo and Holland Purchase to Wm. Peacock. July 11, 1817, the Erie locks were adopted, 90 by 12 feet; Champlain, 75 by 10 feet; prisms, 40 by 4 and 30 by 3 feet.

ORIGINAL ENGINEER CORPS.

The following abstract of engineers employed on the canal, previous to 1826, when they came into use, is taken, with much other information from the valuable paper of Deputy State Engineer S. H. Sweet (Report, Dec. 10, 1862) and other sources:

NAME.	EMPLOYED From	EMPLOYED To	RANK.
De Witt, Simeon	....	....	Surveyor General.
Weston, William	1796	1808	Consulting Engineer.
Wright, Benjamin	1816	1828	Principal Engineer.
White, Canvass	1816	1824	" "
Geddes, James	1808	1837	" "
Gavin, Lewis	1816	1826	" "
Broadhead, Charles C.	1816	..	" "
Bates, David S.	1816	1825	Assistants of various ranks.
Bates, John	1825	....	" "
Bartow, Andrew A	1816	1825	" "
Briggs, Isaac	1818	1821	" "
Clark, John T	1825	....	" "
Eddy, David	1822	....	" "
Ellicott, Andrew A	1817	....	" "
Gill, Valentine	1817	1821	" "
Hammill, Caleb	1818	1821	" "
Hutchinson, Holmes	1819	1841	" "
Hurd, Davis	1822	1826	" "
Hoffman, Anthony M.	1819	....	" "
Jerome, William	1817	1821	" "
Jervis, John B.	1818	1825	" "
Judson, Daniel	1819	....	" "
Lewis, Marshall	1817	1821	" "
McElroy, William	1817	1821	" "
McElroy, Thomas	1818	1820	" "
Ogden, Abraham	1819	...	" "
Peacock, William	1817	....	" "
Roberts, Nathan S.	1818	1838	" "
Rice, J	1822	....	" "
Sargeant, H. G	1824	1828	" "
Thomas, David	1817	1830	" "
Tibbetts, Hiram	1819	....	" "
Vedder, Aaron	1819	....	" "
Vance, David H.	1819	....	" "
Whippo, C. T.	1822	1827	" "
Wright, Benjamin	1796	1808	" "
Wright, H.	1819	....	" "
Young, George W.	1819	1828	" "

Of some of these engineers the following personal notes are of interest:

The services of Wm. Weston were rendered before the Erie was located.

Benjamin Wright, of Rome, his assistant, was a land surveyor. In 1776, he, with Mr. James Geddes, furnished Gen. Van Rensselaer with data for his report of March 21, as chairman of the joint legislative committee on canals. May 17 he was selected to open the work of construction on the middle division, from Rome to the Seneca River, at Rome, July 17. He was considered the leading engineer and was a man of great executive ability. The first boat was named "Chief Engineer," after him, on the opening of October 22, 1819, from Rome to Utica. He was chief engineer of the Delaware and Hudson Canal, afterward.

James Geddes, a land surveyor, was prominently connected with the canals from 1808 to 1837. His surveys of 1808 have been noticed; his report of January 20, 1809, led to the appointment of commissioners, who employed him in continued explorations. From 1811 to 1816 nothing decisive was done. On the western division, in 1816, he was locating lines from Cayuga to Lake Erie. In September, 1818, he was transferred to the Champlain Canal; in 1820 he is named, with Benjamin Wright and Canvass White, as principal engineers at $1,500 salary, and also in 1825, as suspended, in consequence of the Erie and Champlain completion; the latter appears to have been built by him, and he is highly commended in official reports.

Canvass White was undoubtedly the most accomplished engineer of the corps, and was intrusted with the most difficult problems of location and construction on various divisions of the work. In 1816 he was sent to England to procure field and drawing instruments for the work, and to study the Liverpool and Manchester and other canals. In leveling, at that time, the distinction between the land surveyor and the engineer, he was very skillful, and in construction his discovery and use of hydraulic cement was of the greatest value to canal masonry. He was a resident of Whitestown, Oneida County. In 1817, 1818, and 1819 he was engaged in surveys for final location of the western division, being at Salina in 1818, and Canandaigua in 1819. In 1820 he was in charge of the Eastern Division construction, and in 1821 decided the difficult location at Cohoes; in 1822 he located the Glen's Falls Feeder for the Champlain Canal, and was in charge of the work from Troy to Waterford to

* A paper presented to the Western Society of Engineers by Samuel McElroy, C.E., March 1, 1881.

June. In 1824, when his canal work terminated, he was engaged on the Raritan and Delaware Canal, and made the surveys of the Bronx, Byram, and Croton water supply of New York. In 1833 he was appointed, with Major Douglass, on the final Croton surveys, but was unable to serve from other engagements. Familiar with his name from childhood, on the lips of one of his favorite levelers, I have learned to consider him the most accomplished engineer of his date.

Charles C. Broadhead, May 17, 1816, was placed in charge of the Eastern Division surveys. The appointment shows his rank at that date, but the term of his service is not given.

Lewis Gavin, at the same time, was employed on the Champlain Canal, and reported the estimate for its cost, of $871,000, in March, 1817. His service continued to the completion of 1826.

David S. Bates was employed in different capacities from 1817 to 1827. In 1820 he made a report on the survey of the Oswego Canal from Salina, with alternate estimates of $312,599 and $299,519; in 1825 he held rank as a division engineer.

Isaac Briggs, in 1818, was assistant on the middle division (extended) from Utica to Rome, under Mr. Wright, and left the canal in 1821.

John T. Clark, afterward a division engineer on the enlargement, and State engineer, was employed as inspector and weighmaster in 1835.

Valentine Gill had been Surveyor General of Maryland, and was employed as draughtsman under Mr. Wright in 1817; in 1819 he was attached to the party locating an experimental line south of Rochester to Buffalo, under Mr. White's supervision. He was an accomplished gentleman, with a talent for office work rare in those days.

Holmes Hutchinson was early attached to the corps, and in later years acquired an enviable reputation. In 1820 he was serving as "surveyor" at $1.50 per day; in 1825, he was detached as "resident engineer," but continued in the service on prominent works until 1841.

William Jerome is prominent in the early history of the corps. In 1820 he was resident on the Champlain Canal; in 1823 he was in charge as "principal;" in 1826 he was in charge of the Oswego Canal.

John B. Jervis, the veteran engineer of Rome, gave the State a long and valuable term of service. Employed in 1817, by Mr. Wright, as rodman, at $12 per month, and as leveler under Mr. Bates in 1818, he was located at the Salt Point quarries in the winter, under Wm. McElroy. In 1819 he was virtually "resident" between Utica and Rome, and in 1821, from Spraker's Nose to Amsterdam; in 1823, to the Mohawk aqueduct above Cohoes; in 1825 he joined Mr. Wright on the Delaware and Hudson Canal; in 1833 he took charge of the Chenango Canal, and in 1835, of the Eastern Division of the Erie enlargement, which he left in 1836, for the Croton aqueduct. On these and various other public works Mr. Jervis has made an enviable reputation.

William McElroy, of Trenton, Oneida County, was resident on the Middle Division, from Rome to Stony Creek, in 1818; in the winter he was stationed at Salina, procuring lock stone; after this section was built he was in charge at Little Falls, and there made an improvement in sand tamping for blasts. In 1822 he was employed on the Delaware Breakwater, where he died.

Thomas McElroy, in 1818, was in his brother's party, and in the winter, at Salt Point, receiving stone. In 1819, as leveler under Mr. White he was engaged in the explorations from Phelps, Ontario County, to Buffalo by Caledonia, south of Rochester. At this point, on a run of over 55 miles, a bench of Mr. White's was checked within 0·27 foot. The survey condemned the route, and it was abandoned. At Buffalo he assisted Mr. Thomas in the harbor survey, and left the canal in 1820.

Marshall Lewis, assistant, was transferred, in 1819, to the Seneca River improvement.

William Peacock was selected by the commissioners May 17, 1816, to make explorations from Buffalo to the Holland Purchase. His services appear to have ended in that year.

Nathan S. Roberts, of Whitesboro, was not only of great service in the field, but in the schools opened by him for winter study of the assistants and candidates, he also rendered important aid, at a time when opportunities for special education were limited, doing much to make Oneida County the nucleus of the corps it really was. In 1817 he was an assistant on the Middle Division; in 1819 he was on the final location of the Western Division with Canvass White; in 1820 his pay was $4 a day, making him higher than resident; in 1825 he ranks with Mr. Geddes, and continued in prominent services to 1838.

David Thomas, of Aurora, commenced in 1817, and in 1819 was employed on the Buffalo harbor survey, reported by him early in 1820; he was then on the Western Division at $5 per day; in 1824 he was in charge; in 1826 he made the survey for the Cayuga and Seneca Canal; in 1829 he was in charge of the Seneca River improvement.

Aaron Vedder was employed in 1819 in the field party south of Rochester.

David H. Vance was a draughtsman, procured from the Poultney Land Office to assist Mr. Gill in the office work of the same party.

In those primitive days of small salaries engineers were content with much honor and little pay; virtual chief engineers $1,500 a year; division engineers, $4 and $5 per day; residents, $2 or $2 50; assistants, $1 to $1.75; rodmen, $12 per month; expenses were allowed in addition.

CONSTRUCTION.

Following the Mohawk Valley navigation in use, the middle division was first built. A higher level than that of Oneida Lake was adopted, with a long level of 55·65 miles across the divide between the Hudson and St. Lawrence water-sheds, a location well designed for the original canal, but unfortunate for the enlargement, from restricted water supply. It was commenced July 4, 1817, and opened for use October 19, 1819. The location of the Eastern and Western Divisions was delayed, and the entire line from Buffalo to Albany was opened November 3, 1825. The Champlain was opened from the Erie Junction, near Cohoes, to Whitehall, September 10, 1823, including river navigation from Fort Miller to Fort Edward, superseded by canal in 1827.

The cost estimated, March, 1817, by the engineer assigned to each division, was $5,797,738; but the Erie locks were afterward made 90 by 15 feet, and the Champlain enlarged to 90 by 15, and larger sizes, and the prism surface to 50 feet, with a depth of 5 feet. The estimate of 1822 was $7,603,336. The expenditure to 1826 was $9,474,373; this includes Buffalo harbor and various items not strictly canal work, reported at $1,373,629, which, with the Champlain at $921,011, leaves the Erie cost $7,179,733. The cost of the Erie and enlargement, as reported for 1862, was $52,491,915, the work not being then complete.

DIMENSIONS.

		ORIGINAL.	ENLARGED.
Length, Albany to Buffalo	Miles	363	352
Locks	"	Single, 83	Double, 72
		90×15 feet.	110×18 feet.
Prism	Feet	40×4	70× }
"		28×4	56× } 6 to 7
"			52½× }
Boats—			
Limit	Feet	78·62×14·41×3·5	98×17·5×6·41
Cargo, limit	Tons	80	240
Displacement	"	110	303
Speed per hour, 2 horses	Miles	2	1·3
Lockage time, usual	Minutes	6 east, 5 west.	19 east, 11 west.
Trip time, both ways	Days	15	18½
Ascent, going east	Feet		43·62
Descent, "	"		615·3
Capacity, 1 lock	Tons	2,080,000	3,622,500

Structures.—The number and proximate value, on the enlargement in 1862, is thus given by Chief Engineer John D. Van Buren, Jr. Report 1878, p. 83.

158	Iron bridges, 43 square feet each	$0.81	$354,674
382	Wooden bridges, 510 square feet each	0.78	196,178
540	sets Bridge abutments	2,750.00	1,485 000
540	" Bridge embankments	1,800.00	972,000
57	Double locks, aggregate length 9,883 feet	73,850 00	4,209,450
13	Single locks, " " 2,415 "	31,560.00	441,840
2	Single guard locks, " " 345 "	23,000.00	46,000
5	Single weigh locks, " " 737 "	47,036.00	235,180
24	Aqueducts, " " 24,235 "	310.00	7,512,850
	Waste weirs, " " 2,363 "	42.00	99,246
11	Stop gates	2,000 00	22,000
190	Stone arch culverts, spans 1,528 feet	4,000.00	760 000
94	Composite culverts, " 435 "	1,700.00	150,800
	Total		$16,494,218

Some structures increased since 1862.

Branches.—The prominent dimensions of the various branches built, to connect with the main line, are given in the following table:

NEW YORK STATE CANALS.

NAME.	Authorized.	Completed.	Length, Miles.	Size of Prism. Surface ft.	Size of Prism. Bottom, ft.	Size of Prism. Depth, ft.	No. and size of Locks. No.	Length, ft.	Width, ft.	Boat Cargo, Limit, Tons.
Erie—Original	1817	1825	363 00	40	28	4	84	90	15	80
Enlarged	1835	1862	352.00	70	56	7	72	110	18	240
Champlain	1817	1823	66.00	50	35	5	20	100	18	80
Glen's Falls Feeder	1822	1837	12.00	50	35	5	12	100	18	80
River Imp't, Waterford	1822	1837	3.00							
Oswego—Original	1825	1828	38.00	40	24	4	18	90	15	80
Enlargement	1847	1852	38 00	70	56	7	18	110	18	240
Cayuga and Seneca	1825	1828	21.00	40	24	4	10	90	15	80
Enlargement	1835	1862	23.00	70	56	7	11	110	18	240
Black River and feeder	1836	1849	50.00	42	26	4	109	90	15	80
Improvement	1849	1861	42.00				1	110	18	240
Genesee Valley	1826	1861	124.75	42	26	4	112	90	15	80
Chenango	1833	1836	97.00	40	24	4	116	90	15	80
Chemung and feeder	1829	1831	39.00	42	26	4½	53	90	15	80
Oneida River Improvement	1839	1850	20.00	80	60	4½	2	120	30	
Oneida Lake Canal	1832	1836	7.00	40	24	4	7	90	15	80
Baldwinsville and Seneca Improvement	1838	1849	5.75	40	24	4	1	90	15	80
Crooked Lake Canal	1829	1833	8.00	42	26	4	27	90	15	80
Improved			878.50							

CONSTRUCTION AND OPERATION OF NEW YORK CANALS TO SEPT. 30, 1862.

NAME.	COST. Original.	COST. Improved.	COST. Repairs and management.	COST. Total.	Income.
Erie	$7,143,789	$52,491,915	$12,518,860	$65,010,775	$71,783,760
Champlain	921,011	2,647,002	2,206,358	4,943,360	4,127,646
Oswego	465,437	3,612,825	1,450,403	5,063,228	2,022,365
Cayuga and Seneca	214,000	1,584,554	557,934	2,142,488	604,280
Black River	2,954,848	4,239,566	310,233	4,549,799	71,536
Genesee Valley	5,342,753	9,408,896	849,284	10,258,180	568,050
Chenango	2,316,186	3,754,143	690,471	4,444,614	509,374
Chemung	314.395	1,623 693	935,996	2,559 689	375,819
Oneida River	79,346	173,348	185,338	358,686	40.216
Oneida Lake		74,916	113,024	187,940	65,130
Seneca River	14,846	16,585	24,730	41,315	191,139
Crooked Lake	156,776	418,890	11,185	430,075	1,201
Amount		$80,046,338	$19,943,820	$99,990,158	$80,420,431

(To be continued.)

THE BOLLEE STEAM CARRIAGE.

In this article we purpose to give some account of a new steam carriage for common roads, as lately described by Herr Kesseler, before the "Verein für Eisenbahnkunde," of Germany. Figs. 1 and 2 show a goods van for street traffic, and Figs. 3 and 4 a mail carriage. A "steam calèche" on the same principle has for some time run with success at Berlin. We will describe the mail carriage, although the mechanical arrangements are essentially the same in all. There is a single carriage frame, which supports an upright Field boiler at the hind end, and a pair of vertical cylinders at the front end. The crank shaft is continued under the carriage, in the line of its axis, and turns by special gear, to be described hereafter, a transverse shaft, divided in the middle, and of which each half is coupled to one of the hind wheels by a Gall chain. The hind wheels are connected to the frame by ordinary leaf springs; but the front wheels have two transverse springs, one above the other, and connected by vertical bolts, passing through eyes in their ends. On these bolts are hung axle-boxes, in which run the inner ends of short axles, carrying the front wheels. By means of lever arms placed at right angles to the axles, and a steering apparatus, these boxes can be made to turn about the vertical bolts. By this means each front wheel is rendered independent of the main frame, and movable about a vertical axis nearly coinciding with its own vertical diameter. The two springs are connected in the middle by a large casting, through which passes a vertical steering shaft, having a hand wheel at the top, and a spur wheel near the bottom, gearing into a horizontal rack quadrant. This quadrant swings on a pin fixed to the frame, and on the other side of this pin carries two lever arms, set at an angle of about 35° with each other, and one on each side of the axis of the frame. Connecting rods unite these lever arms to the lever arms already mentioned on the boxes carrying the front wheels, which boxes are thus made to swivel about their vertical axis by the action of the steering shaft. But the extent of this action is by no means the same in the two cases. It will be seen by reference to Fig. 4 that when the wheels are swiveled into the dotted position, the lower or right-hand lever in the quadrant has its eye close to the center line of the carriage, and consequently acts upon its connecting rod with a pull nearly at right angles; while the left-hand lever, being far from the center line, acts on its connecting rod with a thrust at a very obtuse angle, and

therefore with much less effect. Hence the two wheels are not in parallel planes, and the lines of their axles, instead of being parallel, meet in some point outside the carriage. This point is so chosen as to be on the prolongation of the hind axle, and, therefore, the lines from this point being at right angles to all four wheels, the point forms the center round which the whole carriage turns with ease and rapidity. This arrangement has the further advantage that the carriage always rests on a safe and level basis.

As already mentioned, the power is conveyed to the driving wheels by a chain and chain wheels, from a divided transverse shaft. By means of what are called addition and substraction wheels, the uniform rotation of the crank shaft is so conveyed to the two parts of this shaft that on curves each wheel receives exactly the velocity required by the different length of path which it may have to traverse. Thus the wheels only *roll* on the road, they do not *grind* upon it, as wheels going at equal speed must do—a defect which has existed in many previous road steamers. The connection between the motive power and the wheels being through springs is very elastic, and the whole motion is as easy and smooth as can possibly be conceived.

The driver sits on an ordinary coachman's box, which also forms the water-tank, and manages the carriage by means of the steering shaft and wheel already described, and by a brake shaft, which passes through the center of the hollow steering shaft. These shafts are straight before him, while on his right hand are the regulator and reversing handle.

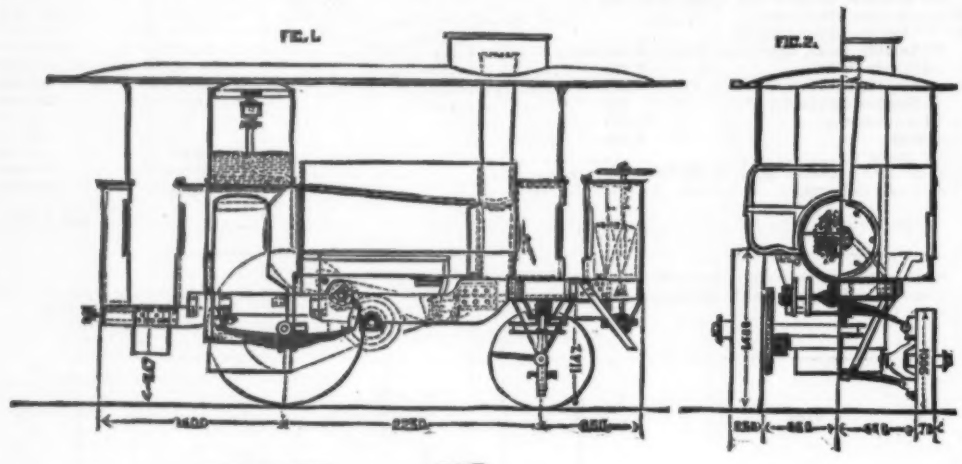
Heating surface, 19 square meters (for 45–50 H.P.).
Coal space, 1 cubic meter (for 8 hours consumption).
Water space, 1,200 liters (for 1¾ hours' consumption).
Speed, 7·2 kilometers per hour.

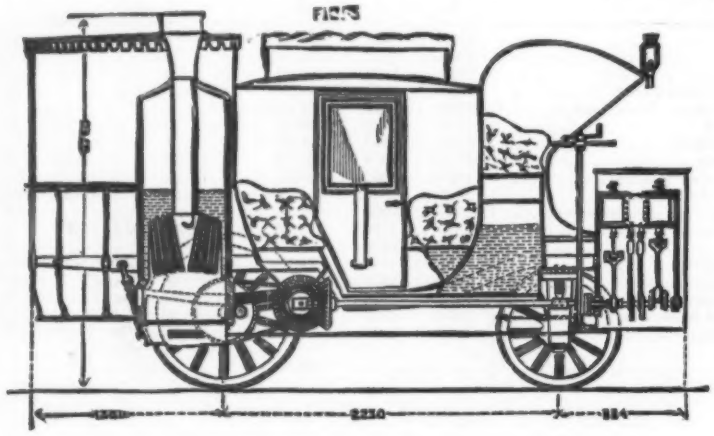
	Kilogs.
Weight of engine, empty	7,500
Weight of engine, loaded	10,000
Load on hind wheels, with full load	7,000
Load on front wheels, with full load	3,000

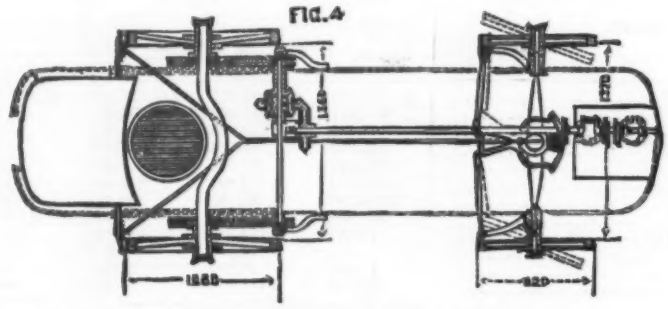
A similar engine, but of three times the power, is now in course of construction.

So little has been heard of late in England with regard to steam carriages on common roads that the above short account of what is certainly a very ingenious specimen of the class cannot fail to be of interest. At the same time, the reception given to the idea, even at the meeting where it was introduced, does not seem to have been altogether favorable.

Herr Kaselowsky, well known for his invention of tire fastenings, gave, in particular, a long and somewhat amusing account of his experiences with an earlier steam carriage built by L. Schwartzkoff, of Berlin, in 1863; and especially of his difficulties with the peasants of the district through which he plied, who not unnaturally looked on the new engine as destined to destroy their ancient and valuable privilege of hauling by wagon. His experience was that, apart from such obstacles, running by steam on common







THE BOLLEE STEAM CARRIAGE.

Between the box and the boiler is the body for passengers, covered with a movable head. The fireman stands behind the boiler, and has a supply of coal for seven or eight hours' run. The consumption of coal on the level is about 1 kilog per kilo. (3·6 lb. per mile), and that of water 270 liters per hour (60 gals.) On a good level road the carriage runs at about eighteen miles per hour, and it mounts inclines of 1 in 12 with ease and safety.

The traction engine for goods, shown in Figs. 1 and 2, is of similar mechanical arrangement to the steam carriage, and has a truck of special construction coupled to it in such a way that the hind wheels of the truck can also be used as driving wheels. It is intended to haul 20,000 kilog.—20 tons—on inclines of 1 in 20, and double that amount on the level. The leading particulars are as follows:

	Millimeters.
Diameter of driving wheels	1,400
Breadth of tires of ditto	250
Width of gauge between tires	1,320
Diameter of leading wheels	900
Breadth of tires of ditto	190
Width of gauge between tiers	1,320
Wheel base	2,250
Total length of engine	3,700
Total height of engine, including spark-catcher	3,100

roads was a very safe, pleasant, and easy amusement in good weather; but that with rain and mud troubles began that gradually wore out the strongest enthusiasm. He gives a vivid, if not a pleasant, description of the descent of a long hill in a damp, dark evening, when the wheels were thick in mud, the brakes refused to hold properly, and the engine and train went bowling down to the valley at a perilous speed, the driver steering his course by the sole help of the successive poplar trees, as they showed dark against the sky, and devoutly hoping that no vehicle would be coming up the hill at that hour, since he must certainly run over it. By good luck and good steering they reach the valley in safety; but the general result of this and similar adventures seems to have been to impress strongly on Herr Kaselowsky's mind the very superior comfort and safety of the iron road, and to make him thankful that railways had been invented. We believe his experience will be confirmed by others.

Those who care to turn back to our issue of October 27, 1871, will find a very lively account of Mr. Crompton's trip from Ipswich to Edinburgh, on the "Thomson" road steamer "Ravee;" and despite his skill and energy in the overcoming of difficulties, they will probably agree that his experiences do not offer great encouragement. The Indus steam train, which Mr. Crompton subsequently worked with so much energy, and which was described by him before the Institution of Mechanical Engineers, in 1879, was finally abandoned; and nothing has been heard of that system of transport in India during recent years, when the exigencies of war and famine might have been thought specially likely to call it forth.

Again, Mr. B. Blackburn exhibited, at the Horticultural Gardens, about two years ago, a "mechanical dog cart" of very ingenious construction, which, as far as starting, stopping, running, and turning are concerned, performed all its duties with entire success. But we have heard nothing of the invention since, and presume that it has proved impracticable to get it fairly taken up. Thus, all experience seems to be against the success of steam carriages, or engines, for rapid traffic on common roads. Of course, the heavy traction engines made by Messrs. Aveling & Porter, and others, for hauling great loads at slow speeds, come under a different category; though, even here, success has only been achieved within a certain limited sphere. Whether the Bollee system, with its undoubted ingenuity, is destined to revolutionize our ideas, and make a road steamer into a success, we will not presume to state positively; but the present experience with it is certainly not sufficient to justify such a claim.—*The Engineer.*

ANNULAR WHEELS.

FORMS OF EPICYCLOIDAL AND INVOLUTE TEETH FOR INSIDE GEAR.—FAILURE OF THE ODONTOGRAPHS TO MEET CERTAIN PRACTICAL CASES.

By Prof. C. W. MACCORD.

IT is remarkable that, while so much has been written about wheels and their teeth, very little of it has special reference to those which work in inside gear. Though not so extensively used as those in outside gear, annular wheels have in many cases peculiar advantages; their employment is sometimes imperative; and the correct formation of their teeth is a problem of no less practical importance than of abstract interest. Yet, in regard to this, we have been unable to find on record instructions which cover all contingencies that may arise even under feasible conditions, except in relation to pin-gearing, which is discussed at considerable length by Prof. Willis in his "Principles of Mechanism."

Pin-wheels, however, are now but little used, except in clockwork and similar light machinery; the system most usually adopted in forming the teeth of spur wheels, whether they are to be cut or cast, is the epicycloidal; and of the peculiarities of this system as applied to inside gearing, Prof. Willis gives no discussion. He does, indeed, give a table of the greatest numbers of epicycloidal teeth that can be assigned to annular wheels working with given pinions. He does not state very clearly how he determined those numbers; but that is of the less moment, because nearly or quite three-fourths of them are incorrect. It is, however, singular that he does not explain the construction of the teeth, because some of the cases included in his table require them to be laid out in a manner which cannot be deduced from anything that he has said.

Prof. Rankine, in his "Machinery and Mill-Work," (p. 117), makes the following brief remark:

"The figures of the acting surfaces of teeth for a pitch-circle in inside gearing are exactly the same with those suited for the same pitch-circle in outside gearing; but the relative positions of teeth and spaces, and those of faces and flanks, are reversed; and the addendum-circle is of less radius than the pitch-circle. *All the rules in the ensuing articles, with these modifications, may be applied to inside gearing.*"

We have italicized the last sentence, because the "ensuing articles" contain only rules in regard to the construction of teeth for outside gearing; which are the same in substance as those deduced by Prof. Willis.

According to these, as is well known, an interchangeable set of wheels may be made, by using for all the tooth-outlines the same describing circle; of which the diameter is limited by the consideration that if it be half that of the smallest pitch circle, that wheel will have radial flanks.

Prof. Rankine, in the paragraph above quoted, plainly states that any wheel of such a set will gear with any annular wheel for which the same describing circle is used. And Prof. Willis says as much, in explaining the mode of using his well-known odontograph.

Both these eminent writers presumably knew that the wheels laid out as above would work in some practicable cases. Had either of them known that in other cases, also practicable, wheels thus constructed will *not* work, there can be no question that he would have deemed it a matter worth investigating; and their failure to perceive this fact can be accounted for, we think, only on the ground of a too hasty generalization. It is not to be disputed that the face and flank simultaneously generated by the same describing circle, geometrically satisfy the condition of transmitting rotation with a constant velocity ratio. But whether they can be practically used or not is another question; and the fact that they always can be if the wheels work in outside gear, does not prove that the same holds true when they work in inside gear.

On the contrary, it is not true; and in the latter case there are considerations relating exclusively to the *internal* tangency of the pitch circles, which fix limits, to the diameters of the describing circles, wholly irrespective of any limit deduced in reference to outside gear.

In consequence of this circumstance, which seems, strangely enough, to have been overlooked by previous writers, it will be found that in many cases, even when the conditions assigned are perfectly practicable, wheels designed to work in inside gear having their teeth laid out in exact accordance with the instructions of Prof. Rankine, as above quoted, or by the use of either Willis's odontograph or that more recently introduced by Prof. Robinson, will not work; the trouble being not in the nature of an irregularity in the motion, but in the more positive form of an interference of the teeth, such that the wheels will not engage at all. Nor are these by any means exceptional cases, or unlikely to occur in practice; on the contrary, they are very likely to be met with, especially in the construction of the differential trains used in hoisting apparatus and other similar mechanism.

A single example will suffice for illustration: let it be required to construct a pinion of 12 teeth, gearing with an annular wheel of 16. We are at liberty by Prof. Rankine's rules, as well as by those accompanying either odontograph, to use for all the tooth-outlines a describing circle half as large as the inner pitch circle, thus giving the pinion radial flanks. The result is shown in Fig. 1; and it will be admitted that it is not a success. The teeth are carefully drawn, of the true epicycloidal form; it is enough to say that within the limits here used, the curves determined by the odontographs agree quite closely with these—what little difference there is tending rather to increase than to diminish the interference of the teeth.

Fig. 1.

Epicycloidal Teeth.
Laid out in accordance with Rules accompanying Willis's and Robinson's Odontographs.

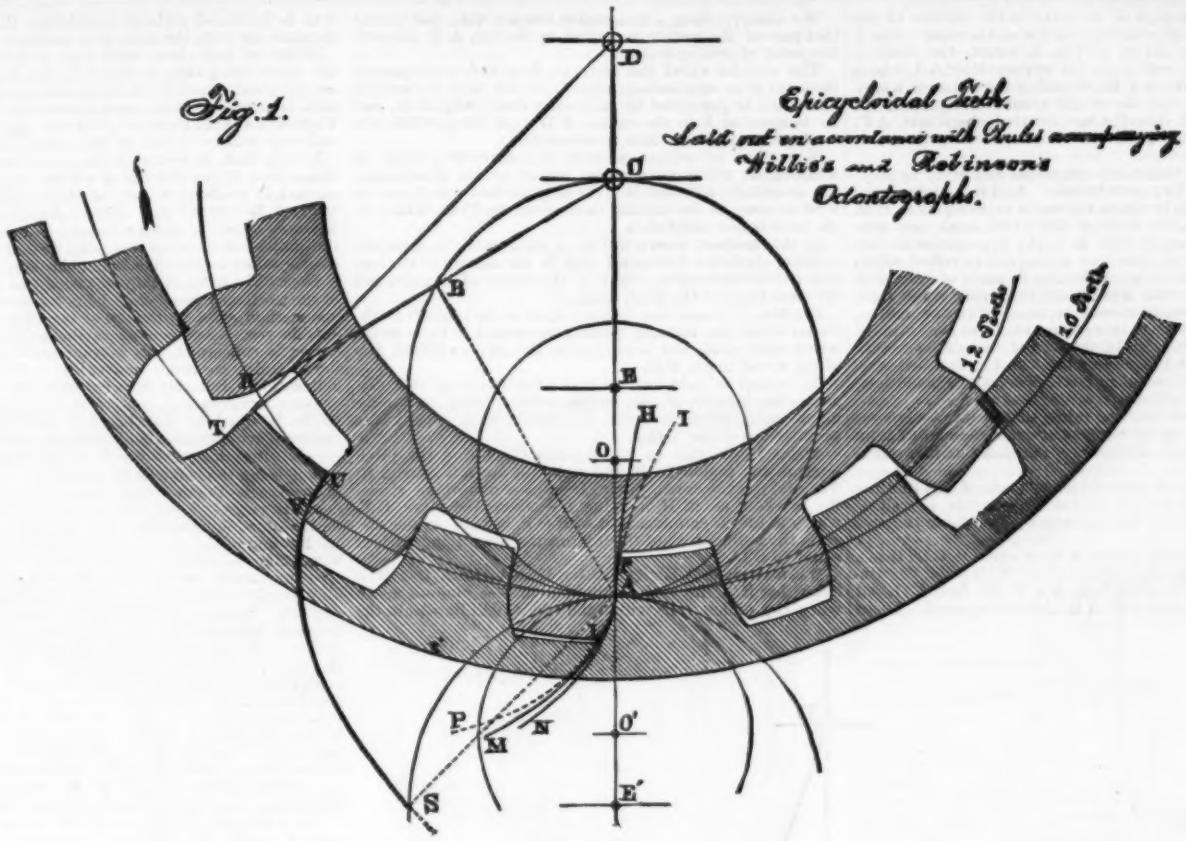


Fig. 2.

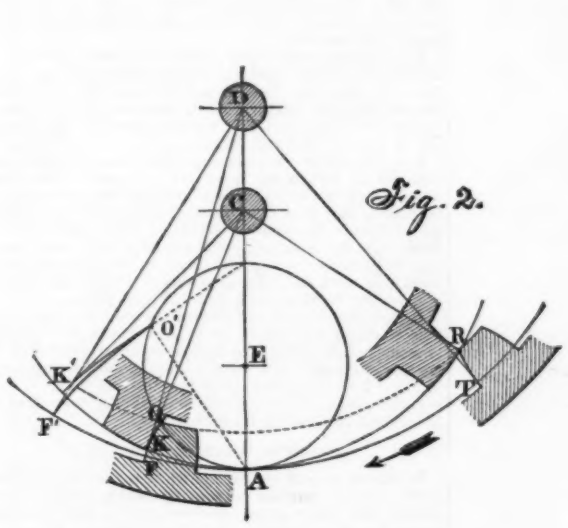


Fig. 3.

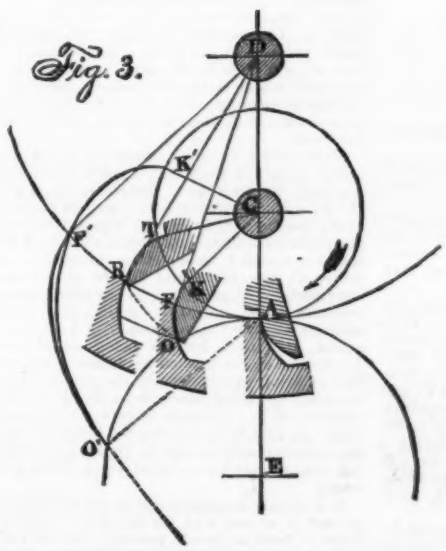


Fig. 4.

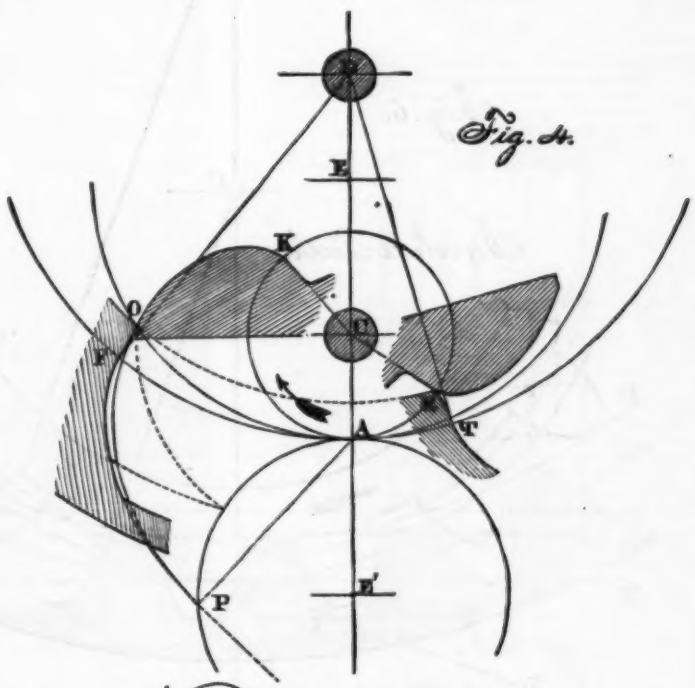
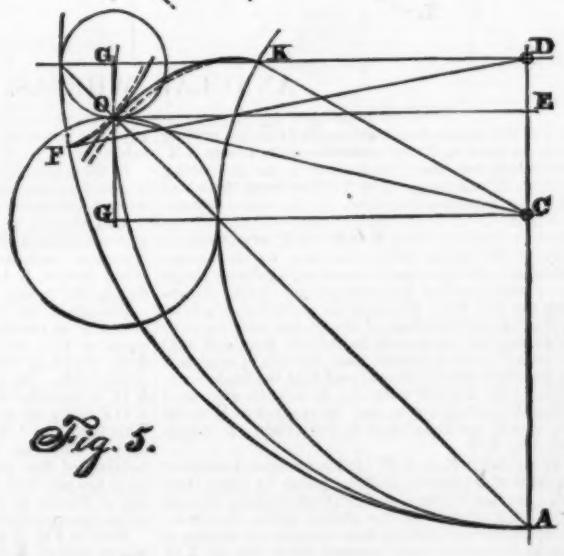


Fig. 5.



ANNULAR WHEELS.

This interference is clearly a radical one, and makes it absolutely impossible to use the wheels as thus laid out; but it does not arise from any abstract unfitness of the curves for the purpose; for they are geometrically capable of transmitting rotation, with a constant velocity ratio.

Thus, supposing the wheel to drive, the arcs, A T, A R, A B, are equal to each other, and the face, T B, is tangent, as it ought to be, to the radius, R C. So again, supposing the pinion to drive, the arcs, A S, A U. A V, are equal, and the curves, U S, V S, are tangent to each other at S as required; these two curves however, intersect between their origins on the pitch circles and the point of tangency, thus illustrating in the clearest manner the fact that something more than the mere compliance with that one abstract condition is necessary to insure the possibility of practically employing them.

Now, the relative motions of such a wheel and pinion while in action are precisely the same as though the wheel were to be rolled around the pinion, and the latter within the former, simultaneously. We must, therefore, be able to perform either of these operations separately; and in

order to do this, the path of no point in the outline of the rolling wheel must intersect the outline of the other. But if we roll the pinion shown in Fig. 1 within the annular wheel, the point, A, will trace the hypocycloid, A I, which lies within the curve A F H, bounding the adjacent wheel-tooth. And if we roll the wheel around the pinion, the same point, A, will describe the internal epicycloid, A P, which lies within the pinion's tooth bounded by the curve A L M.

It is well known that every epicycloid and every hypocycloid is capable of two generations. And if we take an internal describing circle whose radius, A O, is equal to C D, the line of centers, the face of the wheel tooth thus generated will be identical with A I, the hypocycloidal path above mentioned, and thus the pinion can be rolled within the wheel. This describing circle may be made of *less* radius than C D, the face of the wheel tooth then lying to the right of A I; but it obviously cannot be made of *greater* radius.

Again, if we take A O', also equal to C D, as the radius of an exterior describing circle, the face of the pinion's tooth will coincide with A P, enabling the wheel to be rolled upon the pinion. This describing circle also may be made less, but cannot be made greater.

We have, then, this limiting value, that *neither the exterior nor the interior describing circle can have a radius* GREATER *than the distance between the centers of the pinion and the annular wheel.*

However, if either of these circles be made of this limiting radius, the other cannot be used at all; but this, as well as other peculiarities, will be best seen by describing the two cases separately.

Thus, in Fig. 2, let the radius, A E, be equal to C D; then a marking point in the circumference of the interior describing circle will trace, in going from A to O, the face, F O, and the flank, K O, the arcs, A F, A K, A O, being equal. About D, the center of the wheel, describe through O an arc cutting the pinion's pitch circle in R, and make the arc A T = arc A R.

Then considering the inner pitch circle as the describing circle, the point, R, will, in going to A, trace upon the wheel the face, R T, the corresponding flank of the pinion degenerating into a point.

We have seen that the faces, F O and R T, are identical; consequently, if the wheel drive as shown by the arrow, the action begins at R, the wheel-face acting against a single point on the pinion, and the locus of contact during the approach being the arc, R A; the same face will then continue to drive, acting against the flank of the pinion, and the path of contact during the recess will be the arc, A O, and at O the action ends. It is apparent that the arc of approach will be greater than that of recess; and that the pinion can have no face, since if there were one, it must be generated by an exterior describing circle, and be tangent at R to the radius, R C; which would cause it to lie within the wheel-tooth bounded by R T.

In Fig. 3, let the radius, A E, of the exterior describing circle be equal to C D; then a marking point, in going from A to O, will generate the face, K O, for the pinion, and the flank, F O, for the wheel. If the pinion drive, therefore, the action of recess as between these two curves begins at A and ends at O, the locus of contact being the arc A O. But the face of the pinion's tooth may be otherwise generated, thus: describe about C an arc through O, cutting the outer pitch circle in R, and make the arc A T = arc A R; then a marking point in that outer pitch circle, while going from A to R, will describe the face, T R, which is identical with K O.

The corresponding flank for the wheel in this generation reduces to a point, which consequently is driven by T R, this action also beginning at A, ending at R, the path of contact being the arc, A R, of the outer pitch circle.

We observe, then, a remarkable feature, viz., that during that part of the action measured by the arc, A F, *there are two points of driving contact.*

The annular wheel can have no face, and consequently *there can be no approaching action;* for the face, if there be one, must be generated by an interior describing circle, and be tangent at F to the radius, F D, thus lying within the tooth of the pinion, which is impossible.

Now there is another method of constructing teeth in inside gear, which no previous writer, to our knowledge, has described; although it is the only method which can be used in some of the limiting cases given by Prof. Willis in the table before alluded to.

In this method, shown in Fig. 4, the center, E, of the describing circle lies between C and D, the centers of motion; and its circumference, which is the locus of contact, lies between those of the pitch circles.

It will be thus seen that the face, K O, of the pinion's tooth, traced while the marking point goes from A to O, is an internal epicycloid, and acts against the hypocycloidal *face* of the wheel tooth, F O.

No regard is paid to practical proportions in this diagram, the lengths of the acting curves being purposely much exaggerated in order to exhibit more clearly the peculiarities of the action.

About D describe an arc through O, cutting the pitch circle of the pinion in R, and make the arc A T = arc A R. Then taking the inner pitch circle as a describing circle, the marking point, R, in going to A, traces the curve, R T, which is in this case identical with O F, because in the diagram the radius, A E, of the intermediate describing circle is equal to C D.

We may make A E greater; but if we make it less, it is clear that R T, the path of the root of the pinion's tooth when the pinion rolls within the wheel, will lie within the adjacent wheel-tooth, rendering the construction impracticable.

In this case, then, we have the limit, that *the radius of the intermediate describing circle cannot be* LESS *than the distance between the centers of motion.*

And when, as in the figure, this limiting value is used, the action begins at R and ends at O, the pinion driving in the direction indicated by the arrow; the locus of contact being the arc, R A, during the approach, and the arc, R O, during the recess.

But again, the face of the pinion's tooth may also be generated by an exterior describing circle whose radius, A E, is equal to E C; and is, therefore, capable of working with a flank traced by rolling that describing circle upon the outer pitch circle. In order to show this more clearly, the face, K O, is extended to P, the arc A P being equal to A F, and K O P being tangent at P to the flank-curve F P, as required. This flank may or may not be used; but by adding it, we may in this case also secure the advantage that during a portion of the receding action, the face of the pinion will have *two points of driving contact*—a peculiarity of the working of wheels in inside gear which has not, we think, heretofore been pointed out.

Now in Fig. 5 we have an intermediate describing circle, whose radius, A E, is greater than C D; and it generates the faces, O F, O K, which act upon each other as in Fig. 4. But O F may also be generated by an interior describing circle whose radius, O G, is equal to E D, and O K by an exterior one whose radius, O G', is equal to E C, thus making the sum of their radii, G G', equal to C D. These two describing circles, obviously, may be used to generate flank-curves, which will work correctly with the faces, O F and O K; and by adding these we can secure as above explained two points of driving contact during a portion of the action.

From this diagram it is apparent that if either O G or O G' be increased without diminishing the other radius by the same amount, the faces will intersect.

Either or both these radii may, however, be diminished, the result being that, as shown by the dotted lines, the generated face-curves will not touch each other, since they cannot both be generated by the same intermediate describing circle. Their action will, therefore, be confined to the flank-curves, and there will in no case be two points of driving contact.

It will, then, be seen that the *general* law which limits the dimensions of the describing circles in constructing wheels to work in inside gear may be thus stated: *The sum of the radii of the interior and exterior describing circles must not be greater than the distance between the centers of motion;* and the limits first deduced may also be derived by giving particular values to the radii under this law.

Since this is so, it may be urged that the acting outlines of the teeth may in all cases be constructed substantially by one method, viz.: by the use of two describing circles, as in outside gear. And so far as the actual generation of the curves is concerned, this is true; and it may be added that those circles are more convenient to use in the process of delineation. But this does not alter the fact that when the distance between the centers of these interior and exterior circles is equal to that between the centers of the pitch circles, driving contact will continue between the two face-curves after that between face and flank has ended, the action being thus materially modified. And this extension of the range of action and change of the locus of contact depends entirely upon the second mode of generation, by means of an intermediate describing circle. In fact, it is the location of the circumference of this circle which makes it possible to satisfy by means of it conditions not otherwise practicable, and gives to the action peculiarities not at all dependent upon the possibility of generating the faces in any other manner. Thus in Fig. 5, had the condition been imposed that, with a pinion-face limited in height by the radius, C O, the receding action should continue through the arc A K, it is perfectly evident that if the describing circles whose centers are G and G' enable us to satisfy that requirement, the circumstance *must* be due to some such coincidence as the twofold generation of the resulting curves, because the locus of contact extends outside of both of them; and were A O an arc of an ellipse or of a spiral, moving in rolling contact with the pitch circles, the faces thus generated would answer as well as the actual ones here shown, although it were impossible to generate them otherwise.

The contingency just mentioned is one which occurs in several of the limiting cases tabulated by Prof. Willis, so that the teeth can be constructed only in the second manner above discussed, and the correct determination of the greatest number of teeth upon the annular wheel depends absolutely upon a previous determination of the limiting diameter of the describing circle, to neither of which is there to be found a key, or even an allusion, in the "Principles of Mechanism."

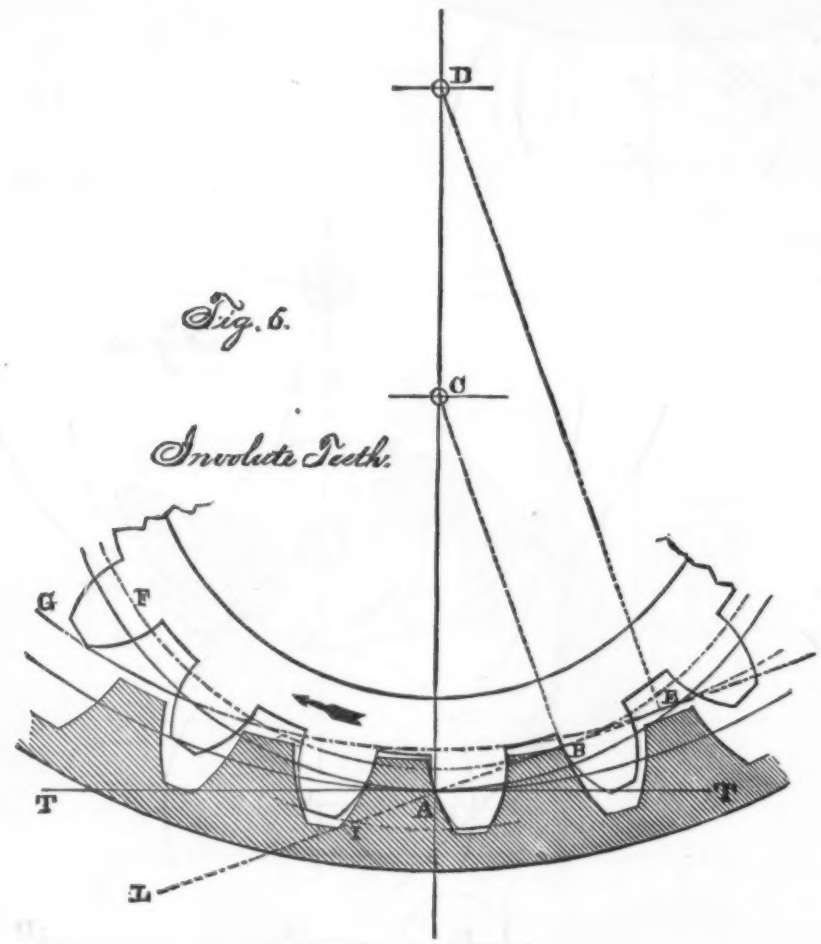
The limiting cases here referred to relate to very low-numbered pinions, and are consequently the less likely to occur in practice. But it is seen from the illustrative example which we have selected, that due regard to the size of the describing circles is equally essential when the number of teeth is relatively large.

It is not within the purpose or the scope of this article to consider at length the questions connected with limiting numbers of teeth; but it will be obvious from what has been said, that if a constant describing circle be used for a set of wheels, the smallest having twelve teeth with radial flanks, the least annular wheel which will gear with that one must have twenty four, and in general, that none of them will work in inside gear unless the annular wheel has at least twelve more teeth than the spur pinion.

It may, however, be questioned whether interchangeability is of so much importance as the securing of the most advantageous action, since the use of internal gearing is more confined to special cases than is that of outside gearing; and in regard to the means of doing this, we think it safe to say that those interested will find in the preceding some points that are both new and useful.

Fig. 6.

Involute Teeth.



ANNULAR WHEELS.

INVOLUTE TEETH IN INSIDE GEAR.

In outside gear, it is well known that the involute form of tooth possesses certain advantages which render it peculiarly eligible where great smoothness of action and perfect constancy of the velocity ratio are required. It is not proposed here to discuss the conditions under which this form may cease to be practicable in inside gear, but that there is at least in some cases nothing to prevent its employment is shown in Fig. 6; C being the center of the pinion, D that of the annular wheel, and A the contact point of the pitch circles. The construction is precisely the same as in outside gear: through A draw the common tangent, T T, and the line of action, L E; the angle between these should not exceed 20°, which is the limit here adopted. Upon L E let fall the perpendiculars, C B, D E; these are the radii of the base circles, B F, E G, whose involutes form the outlines of the teeth.

Since neither involute continues within its base circle, the lowest point of the wheel's tooth which can be used is determined by drawing a circle through B about the center, D; then, if the pinion drive, and its tooth be carried down to its base circle, as in the figure, the action begins at B, the point of contact following the line B L. Suppose the action to end at I, then a circle through that point about the center, C, determines the height of the pinion's tooth; or conversely, if that height be assumed, the same circle determines I, the end of the action; B A, then, is the linear measure of the approaching, A I that of the receding action; and these lengths, being set off on the base circle, determine the corresponding angles of approach and recess. The clearing spaces within the pinion's base circle may be bounded by radial lines, those in the annular wheel by extensions of the involute curves. It is hardly necessary to point out that by increasing the height of the pinion's tooth, the receding action may be prolonged, while the approaching action may be reduced by shortening the teeth of the wheel.

It is clearly impracticable in most cases to secure so long an arc of action with the involute as with the epicycloidal form of tooth in inside gearing: but the fact that the obliquity is constant, by keeping the axes pressed against the bearings with a uniform force, is apparently an advantage in one respect, as tending to produce a very smooth and equable motion.

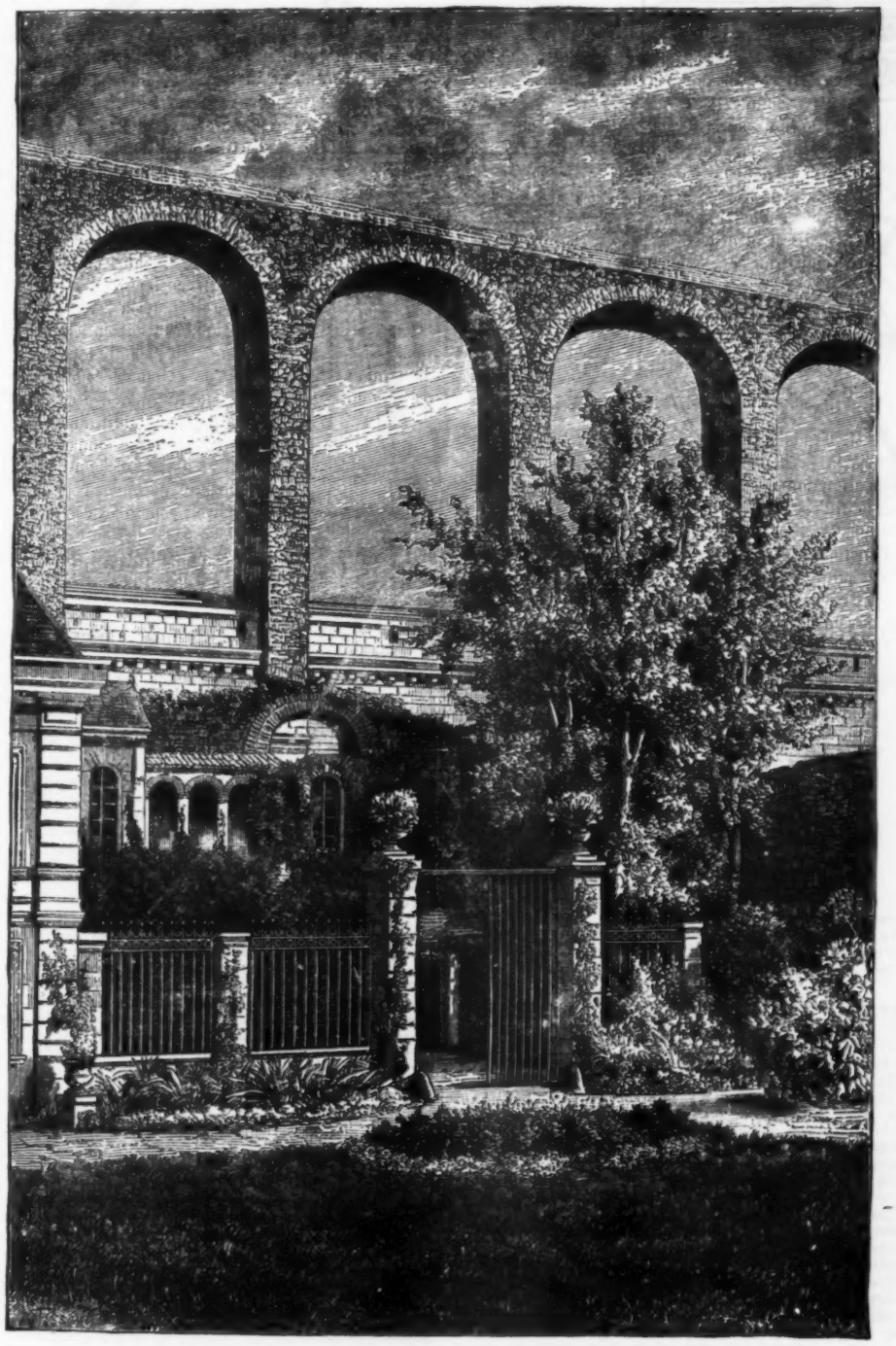
DR. J. R. PAGE, of Baltimore, in the New York *Medical Record*, May 7, 1881, invites the attention of the profession to the topical use of fresh lemon juice as a most efficient means for the removal of membrane from the throat, tonsils, etc., in diphtheria.

THE OLD AQUEDUCTS OF PARIS.

THERE have been three aqueducts erected in succession at Arcueil, over the valley of the Bièvre: the first between the years 292 and 300, by Constantius Chlorus, to supply the baths of his palace of Thermes with spring water; the second, between 1613 and 1624, by the architect Brosse, at the order of Queen Marie de Medicis, chiefly for the needs of her new palace of Luxembourg; and the third, between 1868 and 1875, by the engineer Belgrand, to furnish Parisians with spring water of wonderful purity, gathered up at Champagne and led forty leagues for their wellbeing (see accompanying engraving). The last one—the gigantic aqueduct of La Vanne—follows so nearly the course of the old aqueducts of Arcueil that the digging necessary for its construction brought to light the subterranean ruins of the Roman aqueduct, which was destroyed in the ninth century by the Northmen. It extended farther than the present aqueduct, which has its source at Rungis, and it has been traced as far as Chilly-Mazarin; and between Wissous and Rungis it has been found that there existed a manhole at the place of union of the feeders from whence the principal aqueduct started. As for the Arcueil aqueduct, it is just as Brosse constructed it, and although the water furnished by it is to-day of small consequence in the immense consumption of Paris, it is none the less curious to visit. To examine it properly one should begin at its origin at Rungis; from whence it is possible to walk through its subterranean course as far as the arches of Arcueil or even up to the fortifications. A unique thing to be seen at Arcueil is the collection of remarkable edifices of six different epochs, situated at a few steps from each other. Here the aqueduct of Marie de Medicis ceases to be subterranean and crosses the valley on arches, and this monument is the Arcueil aqueduct properly so called. Upon this old structure of large quarried stones, erected by Brosse, Belgrand superposed the aqueduct of La Vanne of gritstone and cement. Immediately in front of the two central arches of the aqueduct of Louis XIII. there is still standing the face of a wall of the Roman aqueduct made of small dressed stones and courses of bricks. Between these ancient structures is partially set in a small facade of the time of Henri II., of which only a portion can be seen, an elegant gate opening under an arch of the seventeenth century structure. The general aspect is extraordinary. Brosse's aqueduct is 1,245 feet in length, and has twenty-four arches—ten of them open, and 60 feet in height above the Bièvre. Belgrand's aqueduct, which surmounts it, is 3,245 feet long and has seventy-seven arches, and its total height above the same stream is 120 feet.

Belgrand in building the arches of the La Vanne aqueduct over those of Arcueil, in 1869, made two curious discoveries. At about 70 feet beyond the last manhole of the aqueduct he found, under the foundations of the structure of Marie de Medicis, the Roman culvert of beton, in a perfect state of preservation, crossing the aqueduct at a right angle, so that, at this point, three aqueducts—La Vanne, Arcueil, and Constantius Chlorus'—are actually superposed perpendicularly. In 1788, the engineer De Fer undertook the construction of a canal which, wherever it crossed private property, became a covered aqueduct. This was to have led to Paris a portion of the waters of the Bièvre, which were stored up at Amblainvilliers; but work on it was forever suspended during the succeeding year. At some feet beyond manhole number 14, at the point where the Medicis aqueduct enters the ground, Belgrand found, on private property, and in juxtaposition with the Medicis conduit, De Fer's covered aqueduct, so that, including La Vanne, three aqueducts are still united, and within a space of less than one hundred and fifty feet four of them are found.

The waters of the La Vanne aqueduct are carried over the arcade in an enormous cylindrical conduit of beton, having an inside diameter of 7 feet, and which, kept constantly full, discharges a hundred thousand cubic meters of water into Paris every day. The Arcueil aqueduct (the portion of which between the fortifications and the Observatory has been removed and replaced by a cast iron conduit) is now of secondary importance, and discharges its waters into the Pantheon reservoir where they mix with the waters of the Seine.



AQUEDUCT OF LA VANNE, OVER THE VALLEY OF THE BIEVRE, FRANCE

(Beneath are seen the Old Roman Aqueduct and that of Marie de Medicis.)

FARQUHAR'S FILTERING APPARATUS.

IN our SUPPLEMENT, 276, April 16, 1881, we gave an illustration with information of this novel system, and we now present further drawings and particulars:

In a large number of industries the filtration of water is indispensable, yet apparatus for this purpose has not been materially improved in recent years. Experiments have generally been directed toward obtaining the most effective filtering materials and the best arrangement of them; but, as far as mechanical arrangements are concerned, inventors have usually confined themselves to an endeavor to find a means of hastening the operation of filtration either by pressure, vacuum, or centrifugal force. Neither these different means, nor the different arrangements of the interior mechanism, have succeeded in obviating one capital defect inherent to a greater or less degree to all filters, and that is the rapid choking up of the filtering surface. All filters without exception, however good be the filtering material, invariably become choked up after a certain length of time by the impurities retained; and the latter impede and finally prevent the passage of the liquid, and spoil the filtering stratum with which they become mixed, and thus necessitate a frequent and troublesome cleaning. The Farquhar filtering apparatus shown in the accompanying cuts obviates this difficulty by automatically removing the accumulated matters as fast as they form. The following explanation, with a reference to the different figures, will allow the working of the apparatus to be understood. The cast iron box, W, is filled with sand or saw-dust, and is furnished with a movable cover, Q, whose rim fits into a rubber-lined groove in the upper part of the cylindrical box, W, so as to form a tight joint. To keep the cover firmly in place, its edge, as well as that of the box, is furnished with grooves for the reception of bolts. The cover, A, which is made of stamped iron plate, is provided with a stuffing box, R, and is balanced by counterpoises fixed to chains which pass over pulleys mounted on the T-irons that form the uprights, P. M is a bronze collar moving freely on the screw, B, and designed to prevent the contact of the lining of the stuffing box with the screw when the cover is being raised.

To the bottom of the box, W, is bolted a cast iron grating, U, upon which rests a sheet of perforated galvanized iron one-tenth of an inch thick. The holes in the latter are two-tenths of an inch in diameter, and are situated four tenths of an inch from each other. The interior of the box is provided with a flange above the grating for the purpose of supporting a piece of coarse canvas, designed to prevent the sand from passing through the holes in the perforated sheet of iron. Under the grating there is bolted a cast-iron foundation plate, the upper part of which is inclined so as to lead the filtered liquid to the discharge pipe, X. The frame of the apparatus consists of four uprights, P, which are affixed to the projections, T, of the box, W. These uprights are held together at their upper extremities by angle-irons, O. The pulley, L, which carries the driving belt, is mounted on an axle provided with a conical pinion, J, and a disconnecting gear, K, and is supported by the forged iron frame, N. The pinion, J, communicates motion to a bevel wheel, H, which is mounted under a frame, D, and supported by a cross piece, Z. This wheel, H, is furnished with a key which slides freely in the longitudinal groove of the screw, B. Beneath this same wheel there is fixed a cam, G, above which there is a ratchet wheel, F, attached to a bronze nut, C, by bolts. This nut is provided with friction rollers, E, which, rolling over the lower surface of the frame, D, are designed to diminish the resistance that the upward thrust of the screw, B, would offer to motion. The ratchet wheel, F, has a click, A^1, which is pressed by a spring, B^1, into the toothing of the wheel. To the click there is fixed a roller, E^1, against which the cam, G, rubs. The screw, B, is made of cast steel, and is hollow throughout its whole length. Its external diameter is 4 inches, its internal, $2\frac{1}{2}$ inches, and the pitch of the screw, 1 inch. The lower portion of the screw has no thread, and is $4\frac{1}{4}$ inches in diameter. The cap, A, at the top of the screw, is of bronze, has a stuffing box, and revolves freely on the screw. The tubing attached to this cap serves to connect it with the pipe through which arrives the liquid to be filtered.

The disk, H^1, is of cast-iron, and is screwed to the lower end of the screw, B, on which it is firmly held by the bolt, K^1. C is a conical piece of iron fastened to the screw, B, in such a way that its point is in the axis of rotation. The blade, S, of the disk is made of steel; it is three-twentieths of an inch thick and is provided with teeth one-half inch long and one-half inch apart. This blade is bolted at an angle of 45° to the disk, in front of an iron guiding plate, E^1, which also is bolted to the disk at the same angle and at the edge of an aperture in the disk. The blade and the guiding plate are furnished with notches for the reception of the attaching bolts. The part, F^1, is cast in one piece with the disk, and is designed to strengthen the latter at its weakest point. It will be easy now to understand the working of the apparatus.

The material to be filtered arrives at A, descends through the interior of the hollow screw; passes into the channels, G^1, through apertures in the lower part of the screw; flows over the filtering layer, traverses the latter, passes through the canvas, the perforated plate, and the grating, and finally issues purified through the pipe, X.

As above stated, the object of the mechanism of the apparatus is to prevent the accumulation of the residues of filtration on the surface of the filtering materials. This it does in the following manner:

The bevel wheel, H, keyed to the screw, B, carries along, during its rotary motion, both the latter and the disk, H^1, so that the blade, S, drives before it the matters retained by the filtering layer, and these matters, being caught between the blade and the guiding plate, E^1, rise up on to the disk, where they accumulate along with the portions of the filtering material with which they are mixed, thus permitting the liquid to be filtered to always meet a clean filtering surface free from all obstruction.

The cam, G, revolving, presents its hollow part to the roller, E^1, so that the click, A^1, engages with the teeth of the ratchet-wheel, F, until the cam repels it. Owing to this arrangement the ratchet-wheel, as well as the nut, C, to which it is attached, turns a little, and thus causes the screw and the disk to descend slightly. The disk thus follows, in its slow descending movement, the lowering of the filtering surface, and, at the same time, increases the space above it for the storage of the deposits.

When the filtering layer has become so much reduced that it is necessary to renew it, the supply is shut off, compressed air is introduced in order to partially dry the deposit that has accumulated on the disk, the cover is raised, the disk is quickly raised by rotating its axle in the opposite direction, the deposit is removed, the disk again lowered, the cover is

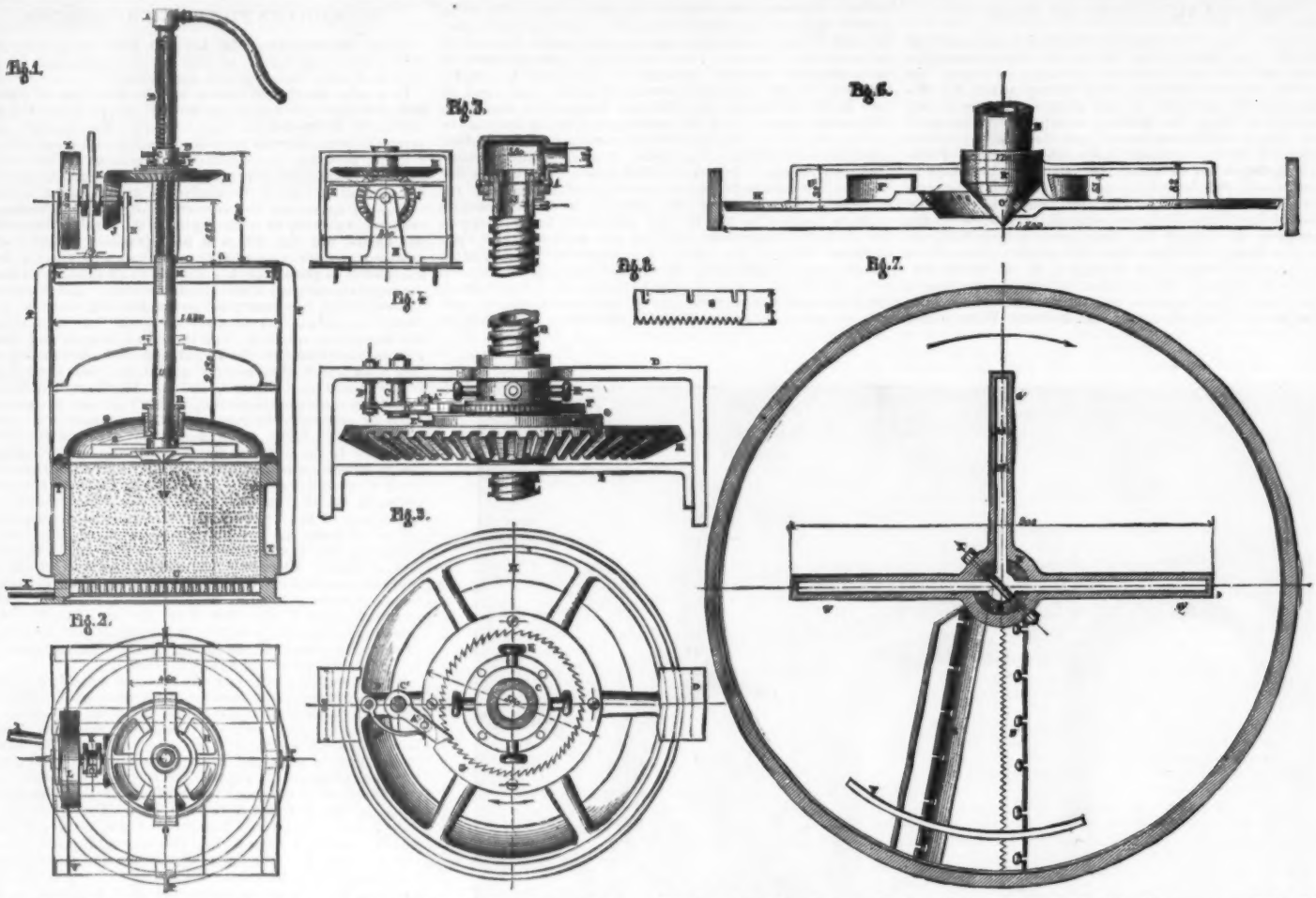


Fig. 1.—Vertical Section. (On a scale of $\frac{1}{10}$.) Fig. 2.—Plan View. (Scale of $\frac{1}{10}$.) Fig. 3.—Cap of the Screw. (Scale of $\frac{1}{5}$.) Fig. 4.—Locking Movement. (Scale of $\frac{1}{4}$.)
Fig. 5.—Plan View of Locking Movement. (Scale of $\frac{1}{5}$.) Fig. 6.—Elevation of the Disk. (Scale of $\frac{1}{10}$.) Fig. 7.—Plan View of the Disk. (Scale of $\frac{1}{10}$.)
Fig. 8.—Blade of the Disk. (Scale of $\frac{1}{5}$.)

FARQUHAR'S FILTERING APPARATUS.

fastened down, and the operation of filtering is begun again without any other cleaning of the apparatus. This interruption occupies about half an hour.

The rotary movement and the lowering of the disk necessarily varies with the liquid to be filtered, and according to the nature of the impurities separated from it; but by means of the gearings it may be regulated at will.

At the rate of eight revolutions per minute, the Farquhar apparatus requires about a two horse power, when the filtering material employed is sand and the pressure of the liquid to be filtered is four atmospheres.

A series of experiments have been made on sewage waters at Asnières, in the presence of Mr. Buffet, engineer-in-chief of Mr. Alfred Durand-Claye, engineer of bridges and roadways, with a filter ten inches in diameter and of the same height, and the delivery obtained was a perfectly clear liquid which flowed continuously at the rate of eleven pints per minute, with a pressure of liquid of one atmosphere. With a pressure of two atmospheres the delivery was fourteen pints.

At the Valette station for dumping night-soil, these experiments were continued on liquid manures, and gave a continuous delivery of a very clear liquid at the rate of two and one-half pints per minute with a pressure of one atmosphere. The filtering layer, although reduced from ten inches to three inches in thickness, continued to furnish a clear liquid. The action of the blade having been stopped in order to see how much influence it exerted on filtration, the deposits began immediately to bar the passage of the liquid, and, in a few minutes, stopped it altogether. As soon as the blade began its work again the filtration went on as before.

This filter has already been used in England for treating the residues of beers remaining at the bottom of vats after clarification by fish glue.

When used for filtering liquid manures, a Farquhar apparatus seven and a half feet in diameter is capable of treating 33,000 gallons in twenty-four hours. A filter of the same dimensions for filtering water for the supply of cities will discharge 132,000 gallons of clarified water in a day of twenty hours, supposing four hours to be devoted to the renewal of the filtering material.

SUGGESTIONS ABOUT STUFFING CUSHIONS.

IN the course of a discussion which took place after Mr. Robertson's lecture at the St. Mark's Technical School, (London, Eng.), on February 18, Mr. Geo. N. Hooper referred to the wasteful practice of trimmers stuffing cushions with a large quantity of horse-hair, and then tying them

FIG. 1.

down and taking the elasticity out. The object of stuffing a cushion was to give it an enduring softness and elasticity. Horse-hair, when curled, formed myriads of minute springs, which gave exactly what was wanted, but English trimmers spoiled their cushions and wasted horse hair by tying them after stuffing, and also stuffed them from the front; whereas the French trimmer, more wise in his generation, tied his cushions before stuffing, and then stuffed from the back, the consequence being that he got the full advantage of the springiness of the horse-hair, while using a smaller quantity of it.

Sketches were made by Mr. Hooper, Fig. 1 showing the English cushion, the curled lines showing the effective portion of the horse-hair, while the straighter ones show the

FIG. 2.

lines of compression, rendering the horse-hair more or less useless.

Fig. 2 shows the French cushions, with all curled lines, showing how every bit of horse-hair tells.—*Saddlers', Harness-Makers', and Carriage Builders' Gazette, for March.*

HEAT IN RELATION TO CHEMICAL ACTION.*

By HENRY ALLEN.

I INTEND bringing before you this evening a few of the results that have recently been obtained by experimenters in the branch of chemistry or physics known as thermo-chemistry.

The production of heat by the chemical action of combustion and the presumption of some definite relation existing between the amount of this action and that of the heat produced is, of course, no novelty; but it may, I think, be safely affirmed that not till within the last twenty years had the amount of heat produced in chemical combinations and decompositions been, except in very few instances, at all accurately determined.

Such determinations are, in truth, very difficult and require considerable knowledge and manipulative skill, both chemical and physical. The difficulties have, however, been for the most part overcome, and determinations are now made with an accuracy which may be considered wonderful when the complications entering into them are justly appreciated.

Considerable advance was made in this direction from 1842–1853 by the experiments of Dulong, Hess, Graham, Andrews and Favre, and Silbermann; but the results obtained by them have been thrown into the shade by the long-continued and delicate researches of two philosophers, viz., the Danish professor, Thomsen, and the French, Berthelot. It is to the latter especially we owe the distinct enunciation of the fundamental principles of thermo-chemistry and their systematic application to observed chemical phenomena, and it is to these principles and their application I would briefly direct your attention this evening.†

We have to deal then with the convertibility of chemical action into heat, and the first questions are: What is heat? and What is chemical affinity? Heat, long regarded as a form of matter, has been proved to be actually a form of motion, producible from and convertible into other forms of motion. Whenever work is done on a machine without producing equivalent mechanical effects, an amount of heat is emitted equal in value to the work lost, and *vice versa*. Moreover there is observed a universal tendency of all kinds of energy to degenerate into a uniform diffusion of heat, and so to become less and less available for the production of work. I shall endeavor to show that in these respects chemical energy resembles other forms of energy.

Chemical affinity may be defined as the resultant of forces which tend to unite one element to others, or to keep united the elements of compound bodies. Suppose this "affinity" or energy to come into play in the case of two elementary gases. The molecules of each gas before combination are undergoing motions of translation, rotation, and vibration. At the moment of combination these molecules may be supposed broken up into their constituent atoms, which are precipitated with intense rapidity upon the atoms of the other.

Heat results, comparable in amount with that produced by the collision of sensible masses of matter, such as a hammer upon an anvil. The molecules of the resulting compound will generally have motions differing greatly from those of the original gases, while their mutual action and distance will also be altered. The whole of the heat produced may be said, in a certain sense, to be due to the expenditure of chemical energy, and in some very few cases it is actually so. In most cases, however, the compound formed has physical properties very markedly different from those of its components, and physical energy comes into play.

For instance, the compound formed may immediately become a liquid, or even a solid; if it remain a gas, its volume may decrease; or its specific heat may be different from the mean of its components—any of which actions will affect the resulting amount of heat produced. In order to obtain the actual heat produced by chemical action, all these interfering actions must be duly allowed for. It is this fact that so complicates calorimetric experiments. Moreover, as we shall see, such determinations can be very seldom made directly, but have to be arrived at from the results of several indirect experiments.

Before passing on to the principles of thermo-chemistry, it will be interesting to give a brief description of some of the principal apparatus used by M. Berthelot in his calorimetric determinations.

(1) Is the apparatus used in ordinary determinations. It consists of the calorimeter proper of platinum, containing water, capacity about 600 c. c., supported on three cones of cork, the latter placed on a thin slab of wood inside an envelope of silvered copper. This again is placed on blocks of cork inside a double envelope of tin, containing water between its sides, and provided with a stirrer; each envelope, as well as the calorimeter itself, has a cover. The tin envelope is covered externally with felt. A thermometer is placed within the calorimeter which can indicate a difference of $\frac{1}{100}$° C., and is generally used as a stirrer. Another thermometer is placed in the water contained in the tin envelope.

(2) Is the apparatus used for the combustion of solids, *e. g.*, sulphur, carbon, etc. It consists of a thin two-necked glass flask, which is placed within the calorimeter. Oxygen gas is introduced by one tube; another, spirally coiled round the flask, carries off the products of combustion. The larger neck is furnished with a cork, through which passes a small tube, also corked, down which is dropped a splinter of glowing charcoal to inflame the sulphur. The latter is placed in a little dish of baked clay, supported by a thin platinum wire.

(3) Is the apparatus employed for reactions which do not take place at the ordinary temperature of the air, but require a heat of nearly 100° C. It consists of three concentric thin

* Read at a meeting of the School of Pharmacy Students' Association, March 24, 1881.

† The data of this paper are taken from "Essai de Méchanique Chimique fondée sur la Thermochimie," par M. Berthelot. Paris, 1879.

test tubes; two long, and of nearly the same diameter, and the third shorter and broader. The solution to be heated is placed between the two long tubes, and this space is closed at the top, but communicates with a tube which is coiled spirally, and passes out at the top of the calorimeter. These tubes are fitted by a stopper into the outer tube, which is empty. Heat is imparted by pouring a definite amount of water at a definite temperature into the innermost tube. This water is heated in the apparatus (shown in 3*a*) by steam, about 25 grammes of water only are used in a calorimeter containing 800 grammes of water, to prevent a rise of temperature of more than 2° C.

Let it be required to determine the heat produced by the decomposition of ammonium nitrite ($AmNO_2$) into N and water. (This decomposition does not take place rapidly under a temperature of 80° C.) Twenty-five grammes of water are heated to about 85° C. in 3*a*, and let run into the inmost tube, which is then closed. The space between the tubes only contains water, as this is a preliminary blank experiment. After ten minutes, a thin-pointed steel wire is introduced, and a hole is made in the bottom of the three tubes. The air in the outermost tube is liberated by piercing the stopper; the water is thoroughly stirred and its temperature noted.

The same process is then repeated with solution of ammonium nitrite between the two tubes instead of water. The nitrogen evolved escapes by the spiral tube and is cooled before leaving the calorimeter.

The amount of nitrite decomposed is estimated either by measuring the nitrogen evolved or by determining the amount of nitrite left in the tube by means of permanganate solution.

A special apparatus is used for the combination of two gases, such as oxygen and nitrogen binoxide, which combine spontaneously and without explosion. A small flask of known volume is filled with the one gas, sealed, and placed inside a larger flask. The volume not occupied by the small flask is then determined and altered, if necessary, to some required multiple of the other. The large flask is then filled with the second gas, sealed up, and placed in the calorimeter, being held in position by a spiral wire. It is then shaken so as to break the small flask at a point that had been previously weakened, and the rise of temperature is noted.

(5) Is an air thermometer, invented by M. Berthelot, for temperatures of over 300° C. It consists of a cylindrical bulb 4 c. c. capacity) furnished with a tube of length 1,200 mm. and internal diameter 0·2 mm., containing air; the other end is fitted with a capacious reservoir and contains mercury. The special advantage of this thermometer is due to the large size of the bulb relatively to the contents of the tube, the former being about one hundred and thirty times that of the latter; this result is that variations in the temperature and pressure of the external air exercise scarcely any influence on the reading.

We come now to the fundamental principles of thermochemistry or chemical mechanics, which I will give in the words of M. Berthelot. They are three:

"(1). *Principle of Molecular Work.*—The quantity of heat liberated in any reaction whatever measures the sum of the chemical and mechanical work accomplished in that reaction.

"(2). *Principle of the Calorific Equivalence of Chemical Transformation, or Principle of the Initial State and the Final State.*—If a system of simple or compound bodies, taken in definite conditions, undergoes physical or chemical changes capable of bringing it into a new state without giving rise to any mechanical effect exterior to the system, the quantity of heat liberated or absorbed as the effect of these changes depen is simply on the initial and final states of the system, and is the same whatever may be the nature and the sequence of the intermediate states.

"(3). *Principle of Maximum Work.*—Every chemical change brought about without the intervention of an extraneous energy tends to the production of a body or a system of bodies which liberates the greatest heat."

As a deduction from which, "Every chemical reaction that can be effected without the assistance of preliminary work and apart from the intervention of an energy extraneous to that of the bodies present in the system necessarily takes place, if it produces heat."

It may render the matter clearer to trace the analogy between these three principles and the familiar phenomena which occur in the case of falling bodies. When a body falls to the earth, the heat evolved by impact on the ground will bear some definite relation to the height from which it fell; and heights might be actually measured in this way, if there were not far readier methods available. Here we have the counterpart of the first principle just enunciated, which asserts that the heat evolved in any reaction measures the amount of work done, *i. e.*, the loss of chemical energy; but in this case the determination of the heat evolved is the only method of ascertaining this loss. Of course it is hardly necessary to say that the production of this heat in no way explains why the reaction takes place, any more than the heat emitted when a body strikes the earth explains the force of gravitation.

Again, whatever be the path taken by the falling body, the work done by its fall is always the same. It may fall perpendicularly, or down an inclined plane, or may describe a parabolic path in the air, but the work done is in every case measured by the perpendicular height of its fall. This is identical with our second principle, which asserts that the heat produced depends only upon the starting point and the result of any series of operations whatever be the intermediate steps.

Finally, a body will always tend to fall as far as it can, and if it is free to fall it will fall. This is the counterpart of the third principle, the "Principle of Maximum Work," which states that the reaction which will evolve the greatest amount of heat always tends to occur.

I shall now endeavor to show the application of these principles: (1) to the determination of the heat equivalents of reactions: (2) to the prediction of various chemical transformations.

There are extremely few cases in which the chemical energy expended in the formation of a chemical compound can be determined by one direct operation and uncomplicated by any simultaneous physical action. Hydrochloric acid is an example. Here 1 vol. of H and 1 vol. of Cl combine to form 2 vols. of HCl; all three bodies are gaseous and there is no condensation. The heat of combination is easily found to be 22 units.

I will explain the meaning of this expression. The unit of heat here adopted is the amount of heat required to raise 1 liter of distilled water from 0° to 1° C.; 22 units then would raise 22 liters of water 1° C. This heat is generated by the combination of 1 gramme of hydrogen with an equivalent weight, *i. e.*, 35·5 grammes of chlorine. Again, the heat of formation of common salt is 97·3, *i. e.*, 1 equivalent or 23 grammes of sodium in uniting with 35·5 of chlorine evolves heat sufficient to raise the temperature of 97·3 liters of water 1° C. Generally, however, some indirect method must be adopted, and the second principle is applied.

This principle admits of very simple experimental verification, *e. g.*, charcoal burnt in excess of oxygen to form CO_2 gives +47 units; when it forms CO it evolves only +12·9; but CO combines with oxygen and liberates 34·1; but 12·9+34·1=47; or the total heat is the same whether CO_2 is formed by two operations or one.

Take a simple case: The heat of $SO_3+BaO=BaSO_4$. The mutual action of two solids is very irregular, and the heat evolved cannot be therefore directly measured with accuracy.

The method of procedure is this: Combine SO_3 with water, combine BaO with water, and mix the two solutions; we have as a result merely $BaSO_4$ and water; but

$$SO_3+H_2O=\text{sol. } H_2SO_4 : +18{\cdot}7$$
$$BaO+H_2O=\text{sol. } BaHO_2 : +13{\cdot}9$$
$$BaHO_2+H_2SO_4=BaSO_4+2H_2O : +18{\cdot}4$$
$$51$$

∴ BaO+SO_3 in combining evolve 51 units.

In other cases use is made of the difference of heats, *e. g.*, to determine the heat evolved by the solution of CO_2 in water, a solution of KHO and a solution of CO_2 (each of definite strength) are mixed: heat evolved =*a*.

Then a similar solution of KHO is mixed with water and a vol. of CO_2 added, so that the resulting solution of K_2CO_3 is of a like strength to that obtained in the previous case; heat evolved =*b*: then *b*—*a* gives the heat of solution of CO_2 =2·8 units.

I will now bring before you a complicated determination, which I hope to be able to make clear, viz., the heat of formation of hydrocyanic acid from its elements. As you are aware, hydrocyanic acid treated with concentrated hydrochloric acid produces formic acid and ammonium chloride.

$$HCN+HCl2+H_2O=H_2CO_2+NH_4Cl : +11{\cdot}15.$$

From the starting point of

$$C+H_2+N+O+_2HCl \text{ sol.}+\text{water}$$

to the final stable condition,

$$CO_2+H_2O+NH_3 \text{ HCl sol.}+\text{water},$$

there are two paths: the one by direct oxidation of the carbon and hydrogen, and the union of hydrogen and nitrogen to form ammonia, which combines with the hydrochloric acid; the other by the union of carbon, hydrogen, and nitrogen to form hydrocyanic acid, the decomposition of the last into formic acid, and the combustion of* the formic acid into CO_2 and H_2O; each should give the same quantity of heat.

(1)
$$C+O_2=94$$
$$H_2O=69$$
$$N \text{ and } H_3 \text{ and } Ag=35{\cdot}15$$
$$NH_3+HCl=12{\cdot}4$$
$$210{\cdot}55$$

(2)
$$HCy=x$$
$$2H_2O=138$$
$$HCy \text{ into Formic A.}=11{\cdot}15$$
$$\text{Combust. of Formic A.}=69{\cdot}8$$
$$x+218{\cdot}95$$
$$x=-8{\cdot}4$$

i. e., 8·4 units are absorbed in the synthesis of HCy.

The method of substitution can often be used with advantage, *e. g.*, to determine the heat of HBr and HI: chlorine liberates Br and I from these compounds, forming hydrochloric acid.

$$Cl+HBr=HCl+Br \text{ (liquid)}=+12{\cdot}5$$
$$\text{but } HCl=22 \therefore HBr=22-12{\cdot}5=9{\cdot}5$$
$$Cl+HI=HCl+I(\text{solid})=+28{\cdot}2$$
$$\therefore HI=22-28{\cdot}2=-6{\cdot}2$$

∴ 9·5 units are *evolved* in the formation of HBr; **while 6·2** units are *absorbed* in the formation of HI.

Enough has now been said to show generally the methods adopted in heat determinations, and I now proceed to show the use that can be made of these results, in accordance with our third principle, which asserts that such reactions as evolve the most heat always tend to take place.

The first happy investigation of the physical conditions which determine chemical reactions was made by Berthollet, who, in 1807, in his "Statique Chimique," propounded the theory, founded upon numerous observations, that chemical reaction is determined by the insolubility or volatility of the products. A more extended investigation shows that while this theory is corroborated in numerous cases, there are others, and not a few, which the theory cannot explain, if it be not entirely contradicted by them; such are the decomposition of insoluble phosphates by strong acids, the decomposition of alkaline cyanides by oxide of mercury, and the decomposition of sulphates by hydrochloric acid, etc. In fact, the theory may be said to hold good as long only as the conditions of the principle just mentioned, viz., the principle of maximum work, are satisfied.

The application of this principle to a few simple and well-known reactions I will now notice.

Nitric oxide combines immediately with oxygen, forming the teroxide or the tetroxide, according to the proportions present: *i. e.*,

$$2NO+O=N_2O_3 : +21 : 2NO+O_2=2NO_2 : +34.$$

The latter reaction disengages more heat, and, therefore, will take place when there is sufficient oxygen present. A comparison between the heats of formation of the several oxides of nitrogen is instructive.

It will be seen that all these numbers are negative, *i. e.*, heat is absorbed in each case: the oxides, therefore, do not admit of direct synthesis from their elements; the heat, too, of nitrous oxide is less negative than that of the others; it is, therefore, the most stable, and is not attacked by oxygen.

$$\tfrac{1}{2}\,N_2O=-9$$
$$NO=-43{\cdot}3$$
$$\tfrac{1}{2}N_2O_3=-32{\cdot}8$$
$$NO_2=-34{\cdot}3$$
$$\tfrac{1}{2}N_2O_5=-22{\cdot}3$$
$$HNO_3=+12{\cdot}3$$

The difference between the fourth and fifth members of the group is small, and this explains the fact that the peroxide does not admit of direct production from the tetroxide; the latter, however, is easily converted into nitric acid in the presence of water, as the numbers indicate. These oxides of nitrogen are all familiar bodies; upon what principles can we then explain their formation? The first two can be produced by heating ammonium nitrate, the formation of which evolves 75 units; when it is heated it decomposes in various manners.

$$NH_4.NO_3=N_2O+2H_2O : 118-18-75=25$$
$$=N_2+O+2H_2O : 118-75=43$$
$$=N_1+NO+2H_2O : 118-75-43=0$$

In each decomposition, except the last, heat is evolved; they are, therefore, all possible; the heat required for the formation of the oxides being supplied by that evolved by the production of water.

The formation of water develops much heat; oxygen and hydrogen will not, however, combine spontaneously; some preliminary work has to be done upon them, by heat, etc., which is perhaps spent in resolving the molecules into their constituent atoms. The amount of heat=29·1 for water in the gaseous state, 34·5 in the liquid state, 35·2 in the solid state, the difference being due to the latent heat of steam and water respectively. The production of hydrogen peroxide evolves only +23·3 units, and therefore this body is never formed when hydrogen burns in excess of oxygen; to produce it oxygen is made to combine with BaO=+5·9 and BaO_2 is then decomposed by HCl giving +11. The energy required is thus supplied indirectly.

It is interesting to note the part played by the excess of energy contained in such bodies as hydrogen peroxide and others that absorb heat in their formation. This oxide is a powerful oxidizing agent, and its potency is often explained by saying that the oxygen liberated by its decomposition, being in the nascent state, has a greater tendency to enter into combination than when it is in its ordinary condition. Without denying the existence of this "nascent state," it may suffice to say that such an assumption, both in this and many other cases, is perfectly gratuitous. For instance, hydrogen dioxide decomposes into water and free oxygen with the production of 11·2 units of heat, or 44·8 units for each molecule of oxygen produced. This heat, if confined to the products of the decomposition, would raise them to a temperature of about 1,000° C., and is therefore quite sufficient to explain the superiority of the body under consideration over free oxygen as an oxidizer. It is possible, however, to regard this amount as being the heat produced in the formation of a molecule of oxygen from its atoms, less the heat absorbed in the decomposition of the dioxide. The peculiar reactions of ozone can be, perhaps, best explained in the same way.

$$\tfrac{1}{2} : 2O_3=3O_2 : +29{\cdot}6.$$

Again, it is known that hydrogen dioxide acts in a peculiar manner upon oxide of silver, the reaction being

$$Ag_2O+H_2O_2=H_2O+Ag_2+O_2.$$

The decomposition has been explained upon the ground of the attraction of the atoms of oxygen for each other, which is thought sufficient to upset the unstable compounds in which they were existing. But if it is considered that the heat of Ag_2O is only +3·5, while that of H_2O_2 is —11·2, the reaction will be seen to evolve heat to the amount of 11·2—3·5=+7·7, an amount quite sufficient to account for the result apart from any atom attraction, though it is probable that the latter may occur.

A study of the compounds of the haloid elements and their relations to each other and to other bodies is very interesting from a calorimetric point of view. I will first call your attention to the following table, which gives the heat of formation of several compounds of hydrogen in different states:

			Result a gas.	Result a dilute solution.
H	Cl	=HCl	+22	+39·3
H	Br (gas)	=HBr	+13·5	+33·5
H	Br (liquid)	=HBr	+ 9·5	+29·5
H	I (gas)	=HI	— ·8	+18·6
H	I (solid)	=HI	— 6·2	+13·2
H_2	S (gas)	$=H_2S$	+ 3·6	+ 5·9
H_2	S (solid)	$=H_2S$	+ 2·3	+ 4·6
H_2	O	$=H_2O$	+29·5	+34·5

It will be seen at once that heat is developed by the substitution of chlorine for Br, I, and S in these hydracids, and therefore that the latter should be decomposed by chlorine, which is the case. Bromine, too, displaces sulphur and iodine easily. The mutual relations of sulphur and iodine offer some complication.

In dilute solution iodine should decompose H_2S with the decomposition of sulphur and formation of hydriodic acid. On the contrary sulphur ought to decompose anhydrous hydriodic acid with liberation of iodine. This has been found to be so; and it is further indicated by the fact that it is impossible to produce a solution of hydriodic acid above a certain strength by the action of iodine upon sulphureted hydrogen. The limit observed corresponds to the commencement of the production of anhydrous hydriodic acid which can exist in a concentrated solution, the action continuing as long as there is only a stable hydrate of the acid present.

According to the numbers given, oxygen should displace sulphur in sulphureted hydrogen, as it does.

For chlorine and oxygen theory indicates a thermic equilibrium in solution, chlorine should decompose water thus:

$$Cl_2+H_2O+\text{water}=2HCl+O+\text{water} : +4{\cdot}8$$

On the other hand anhydrous HCl should be decomposed by oxygen:

$$O+2HCl=Cl_2+H_2O : +7{\cdot}5$$

The former reaction is well known; the latter has been accomplished by electricity and by heat—a mixture of oxygen and hydrochloric acid gas passed through a red-hot porcelain tube is partially decomposed with production of water and free chlorine. The incompleteness of the action is due partly to the dissociation of the water vapor and partly to the inverse action that occurs on cooling.

Finally, oxygen decomposes hydrobromic acid slowly and hydriodic readily, whether gaseous or in solution—a result agreeing with theory.

I will now notice some distinctive features of hydriodic acid. This body, under certain circumstances, is capable of acting as a powerful reducing agent, thus differing greatly from the corresponding compounds of chlorine and bromine. Thus a strong solution of hydriodic acid is decomposed by sulphurous or sulphuric acid, the latter acids being reduced to H_2S and iodine being deposited:

$$SO_2+6HI=H_2S+2H_2O+3I_2 : +55{\cdot}4$$
$$H_2SO_4+8HI=H_2S+4H_2O+4I_2 : +68{\cdot}9$$

* $H_2CO_2+O=H_2O+CO_2$.

On the contrary, in dilute solutions, iodine oxidizes sulphurous acid:

$$SO_2 \text{ sol.} + 2H_2O + I_2 = H_2SO_4 + 2HI : +10{\cdot}5$$

This positive quantity is produced by the solution or rather combination of anhydrous hydriodic acid with water which disengages +19·4. A dilute solution of sulphurous acid is oxidized by bromine or chlorine; hydrochloric acid has no reducing action on sulphuric acid; hydrobromic acid acts thus:

$$H_2SO_4 + 2HBr \text{ (gas)} = SO_2 + 2H_2O + Br_2 \text{ (liquid)} = -3{\cdot}8:$$

the sign being minus: the reaction is explained by the fact that some of the anhydrous acid combines with the water produced, developing heat which more than compensates for that absorbed by the reduction.

The reduction of organic bodies by hydriodic acid affords still more definite confirmation of the principle we are considering. The concentrated acid decomposes alcohol thus:

$$\left.\begin{array}{l} C_2H_6O + HI = C_2H_5I + H_2O \\ C_2H_5I + HI = C_2H_6 + I_2 \end{array}\right\}$$

There are here two actions, each evolving heat:

$$\begin{array}{lll} 2HI = & H_2 + I_2 & : 2\times 0{\cdot}8 = +1{\cdot}6 \\ C_2H_6O + H_2 = & C_2H_6 + H_2O & : \quad +23 \\ & & \overline{\quad\quad 24{\cdot}6} \end{array}$$

If the dilute acid were used 2HI dil. $= H_2 + I_2 +$ water:

$$-37\ 2\left\{\begin{array}{l} 18{\cdot}6\times 2 \end{array}\right\}$$

i. e., more heat would be absorbed than is evolved by the reduction, in fact the dilute acid has no action upon alcohol. By referring to the table it will be seen that no such reduction can occur if hydrobromic acid or hydrochloric acid be substituted for hydriodic; the heats absorbed being $-27(2\times -13{\cdot}5)$ and $-44(2\times -22)$ respectively. I will next direct your attention to the second table in order to point out some relations between the haloid salts of the metals and the corresponding oxides and sulphides that possess thermic interest.

Metal combined with	O.	Cl.	Br.	I.	S.	Oxide combined with	H_2S.	HCl.	HCl dil.
Na	50·1	97·3	90·7	74·2	51·6		3·85		13.7
Ca	66	85·1	75·8	59·3	46	BaO	9		13.55
Mn	47	56	50	34					
Zn	43·2	48·6	43·1	30	21·5		9·6		9·8
Fe″	34·5	41	35	19	11·9		7·8		10·7
Fe‴	31·9								
Al	65·3	53·6	44·2	28·8					
Pb	25·6	42·6	38·5	20·6	8·9		13·3	25	7·7
Hg″	15·5	31·4	30·4	22·4	9·9		34·35	26·75	9·45
Ag	3·5	29·2	27·7	19·7	1·5		27·9	27·9	20·6
Au‴	1·9	7·6							
As^{ous}	77·3	69·4	59·1	28·8					
P^{us}	181·9	107·8							
P^{ous}	?	75·8	54·6	26·7					

From these data some obvious consequences may be deduced.

Each chloride will be seen to have a higher number than the corresponding bromide, and each bromide than the corresponding iodide; bromine will therefore replace iodine, and chlorine will replace both iodine and bromine in every case.

Chlorine should displace oxygen from all the metallic oxides with one exception. Such displacement actually occurs, though generally requiring the assistance of heat. In the case of the alkalies and alkaline earths the excess of energy is sufficient to form hypochlorites and such-like bodies, which, however, are decomposed at a higher temperature.

Chloride of aluminum, on the contrary, is decomposed, though incompletely, by oxygen at a red heat.

It is, however, possible to prepare the chloride from the oxide, using the energy of the combustion of charcoal, viz., 14·4, which surpasses the heat (11·7) absorbed:

$$Al_2O_3 + 3Cl_2 + C_3 = Al_2Cl_6 + 3CO.$$

Chloride of manganese, too, is decomposed by oxygen, contrary to the numbers here given, but the result is due to the formation of a higher oxide, which has a heat of 58 cir.

The relations of bromine and oxygen need not be discussed; bromine displaces oxygen in most cases. Bromide of aluminum, on the contrary, when red hot takes fire in dry oxygen with the formation of the oxide and free bromine.

The mutual relations of iodine and oxygen require a more detailed notice. According to the table iodide should displace oxygen from combination with sodium and potassium, a result first observed by Gay-Lussac, the action occurring at a low red heat. On the contrary, at about 400° iodide of potassium absorbs oxygen, with formation of basic iodate and an iodized iodide. The formation of the iodate, liberating about 44 units, compensates for the oxide formed at the expense of the iodide. This action, I may say in passing, explains the difficulty of preparing an iodide entirely free from iodate and alkali.

The iodides of calcium, zinc, and iron, are easily decomposed by oxygen, the case of iodide of iron being very familiar. Manganous iodide takes fire in oxygen. The vapor of aluminum iodide becomes explosive when mixed with the same gas. All these actions are seen to agree perfectly with theory. It will be noticed that the difference of heat units between the oxide and iodide of Al is much greater than that for any other metal given.

The numbers, in the case of lead, are nearly equal. Accordingly, iodide of lead is decomposed when heated in a current of oxygen, and oxide of lead is similarly decomposed by iodine.

Lastly, there are two metals, Hg″ and Ag, whose iodides are not attacked by oxygen, while their oxides are readily decomposed by iodine. In this case also, the law of maximum work holds good.

We have seen that generally chlorine has greater affinity for the metals than oxygen; in the group of metalloids, however, to which phosphorus and arsenic belong, oxygen readily displaces all the haloid elements from their combinations. The compounds of boron and silicon give similar results.

Decomposition of Water by Metals.—The combining energy of water being about 34, all the metals in the list down to aluminum should be able to effect its decomposition. Na and Ca do so in the cold, the rest when heated. Between iron and hydrogen there is equilibrium; this is indicated by the fact that the iron can be reduced by hydrogen, and oxidized by steam. The insolubility of alumina, which covers the metal in a thin film, prevents the decomposition in this case. Lead, though falling below 30, at a high temperature decomposes water, but the action is here complicated by dissociation. At a lower temperature, hydrogen reduces oxide of lead and oxide of silver.

Action of Hydrochloric Acid.—The limit of the action of the dilute acid (heat=39) is at lead. The concentrated acid, on the other hand, should be decomposed by all the metals here, except gold. In the case of mercury and silver, a heat of 500–600° C. is required to effect the decomposition.

Hydrobromic and hydriodic acids are completely decomposed, even in the cold, by all the metals as far as silver, with evolution of H. A word as to the mutual displacements of these hydracids and their salts. We have seen that chlorine displaces bromine and iodine from combination; this occurs in the case, *e.g.*, of silver:

$$AgI + Cl = AgCl + I, \text{ etc.} : +9{\cdot}5.$$

On the contrary, hydriodic acid attacks chloride of silver, forming iodide and free hydrochloric acid. This reverse action can be very easily explained; thus:

$$\begin{array}{l} AgCl + HI = HCl + AgI \\ +29{\cdot}2 - 8 \quad +22 \quad +19{\cdot}7 : \quad -28{\cdot}4 + 41\ 7 = +13{\cdot}3 \end{array}$$

the difference between HCl and HI being greater than that between AgCl and AgI heat is evolved by this reaction. A similar reaction occurs with other metals.

Sulphides.—The attraction of sulphur for the metals decreases from sodium to silver. On the contrary, hydrogen sulphide attacks the oxides increasingly in the same order. The heat evolved in the case of Hg and Ag is at once seen to be due, not to the combination of the metal with the sulphur, but to the attraction of the hydrogen of the acid for the oxygen of the oxide. All the sulphides down to iron are decomposed by dilute HCl; those below only by the concentrated acid. These facts agree with the thermic equivalents.

The action upon metals of acids containing oxygen presents some peculiar features.

(1.) Sulphuric acid when dilute acts as HCl, liberating H, and forming a sulphate. When concentrated, it is often without action in the cold; but when heated it is reduced by the metal (or by the hydrogen liberated) to sulphurous acid; the reaction in the case of copper being:

$$Cu + 2H_2SO_4 = SO_2 + 2H_2O + CuSO_4.$$

The heats of formation being:

$$\begin{array}{l} +2\times 96{\cdot}7 : +34{\cdot}5 : +2\times 29{\cdot}5 : +91{\cdot}8. \\ \quad = 193{\cdot}4 : = 185{\cdot}3. \end{array}$$

The results (=—8·1) would seem to indicate the impossibility of such a reaction; while it is evident that still less can any simple substitution of Cu for H take place (91·8—96·7=—4·9). If, however, it be remembered that sulphuric acid undergoes dissociation upon heating ($H_2SO_4 = H_2O + SO_3$), all difficulty is removed. The actual equation will be:

$$\left.\begin{array}{l} Cu + SO_3 = CuO + SO_2 \\ CuO + SO_3 = CuSO_4 \end{array}\right\}$$

$$\text{or } Cu + 2SO_3 = CuSO_4 + SO_2$$

$$2\times 51{\cdot}5 : +91{\cdot}8 : +34{\cdot}5$$

$$= 103 : = 126{\cdot}3 \text{ and } 126{\cdot}3 - 103 = +23{\cdot}3$$

In this case a further action occurs, some sulphide being formed:

$$Cu + 2SO_3 = CuS + CuSO_4$$

$$+69 : +5{\cdot}1 : +91{\cdot}8 \text{ and } 96{\cdot}9 - 69 = +27{\cdot}9.$$

(2.) *Nitric Acid.*—This acid never forms nitrates by simple substitution of metal for hydrogen, but decomposes, giving oxygen, which combines with the metal, the resulting oxides being attacked by more acid. Two molecules of the acid ($2HNO_3$ or $HO_2N_2O_5$) furnish, according to circumstances, 1 to 5 atoms of oxygen, nitrogen, or one of its lower oxides, or a mixture of these being simultaneously formed.

The heat of formation of nitric acid is (liquid) 19·9.

" " " " " (solid) 20·5.

" " " " " (solution) 27·1.

The heat of solid nitrate of silver is only +7; that of ferric nitrate +33·4; the former could not therefore be produced directly; the latter might theoretically with evolution of heat 33·4—20·5=+12·9 or (dilute) 30·4—27·1=+3·3; the actual reaction, however, is:

$$\left.\begin{array}{l} Fe_2 + H_2O.N_2O_5 = Fe_2O_3 + H_2O + 2NO \\ Fe_2O_3 + 6HNO_3 = Fe_2 6NO_3 + 3H_2O \end{array}\right\}$$

The heat is $H_2O\ N_2O_5 = H_2O + N_2O_3 + O_2$.

$$27{\cdot}1 : +34{\cdot}5 : -43{\cdot}3 : \quad +34{\cdot}5 - 70{\cdot}4 = -35{\cdot}9,$$

i. e.,—12 for each equivalent of oxygen. The oxidation of iron evolves +31·9, the combination of more acid with the oxide formed:

$$\left.\begin{array}{l} H_2O = 34{\cdot}5 \\ Fe_2 6NO_3 = 30{\cdot}4 \end{array}\right\} = 64{\cdot}9$$

$$Fe_2O_3 = 31{\cdot}9,\ 64{\cdot}9 - 59$$

$$HNO_3 = 27{\cdot}1, \quad = 5{\cdot}9$$

$$\overline{59}$$

+5·9; the total heat, therefore, will be—

$$5{\cdot}9 + 31{\cdot}9 - 12 = +25{\cdot}8.$$

I have no time to enter into an examination of the reciprocal displacements of acids and of bases, though the subject is most interesting. I may just briefly allude to the double decomposition of neutral salts. The terms strong and weak, applied to acids and bases, are familiar, but vague. M. Berthelot has given a precise definition. The term "weak" be applies to an acid or base the salts of which are more or less decomposed by solution in water into free acid and base. Salts not so decomposable are formed by a union of a "strong" acid with a "strong" base. Adopting this definition, the general rule of decomposition is that the strong acid combines with the strong base, and the weak acid with the weak base; in other words, the most stable and the least stable are the salts formed.

For instance, when a solution of ammonium nitrate is mixed with a solution of potassium carbonate, a double decomposition occurs; ammonium carbonate and potassium nitrate are formed. This is indicated by the following numbers:

$$K_2CO_3 + 2AmNO_3 = Am_2CO_3 + 2KNO_3; —3{\cdot}1 \text{ (absorbed).}$$

On the contrary, $Am_2CO_3 + 2KNO_3$ mixed in solution neither absorb nor evolve heat. The heat of each of the four salts in solution is:

$$\left.\begin{array}{l} \frac{1}{2}K_2CO_3,\ 12{\cdot}9 : \ AmNO_3,\ 12{\cdot}5 = 25{\cdot}4 \\ \frac{1}{2}Am_2CO_3,\ 8{\cdot}5 : \ KNO_3,\ 13{\cdot}8 = 22\ 3 \end{array}\right\} \text{ difference } = -3{\cdot}1.$$

It will be said that this absorption of heat is in direct contradiction of the principle of maximum work. It must be remembered, however, that the salts are here in solution; if their heats of formation in the solid state be used in the calculation, it will be found that heat is evolved, as it should be.

In this case, the ammonia is a weak base, and its nitrate accordingly suffers in solution a partial decomposition, giving a little free ammonia and a little free nitric acid. This nitric acid attacks the carbonate of potash, and disturbs the equilibrium; more nitrate of ammonia decomposes, and the reaction continues till complete.

Take another example:

$$Na_2SO_4 \text{ (solution)} + ZnA'_2 \text{ (solution)} : +{\cdot}45 \text{ (evolved).}$$

$$2NaA' \text{ (solution)} + ZnSO_4 \text{ (solution)} : -{\cdot}34 \text{ (absorbed).}$$

It might be thought that acetate of zinc decomposed sulphate of soda; but, in fact, the opposite reaction takes place:

$$Na_2SO_4 + ZnA'_2 = 2NaA' + ZnSO_4,$$

the heat evolved in the first case being due to the dilution of the acetate of zinc solution, which evolves more heat than the dilution of three other solutions together. The heat of the anhydrous salts proves the reality of the decomposition:

$$\begin{array}{lll} ZnA'_2 & : 3{\cdot}3 : \frac{1}{2}ZnSO_4, & 11{\cdot}9. \\ \frac{1}{2}Na_2SO_4 & : 34{\cdot}7 : \quad Na_2A', & 18\ 3. \\ & \overline{\quad 38} & \overline{\quad 30{\cdot}2}. \end{array}$$

$$38 - 30{\cdot}2 = +7{\cdot}8 \text{ (evolved).}$$

Let me here give an instance of the use of heat measurements to measure slow decomposition of weak salts by water, *e. g.*, ferric acetate. This body gradually decomposes in solution into basic acetate, which remains in a pseudo-solution, and free acetic acid.

The fresh solution treated with solution of potash evolves	+ 8·87.
The same solution kept two months	+10·39.
After eighteen months	+12·8.
A solution, six times as dilute, kept only three weeks	+12·82.
The fresh solution heated to 100° C., and then cooled	+12·72.
The last three numbers indicate the liberation of nearly all the acetic acid, the heat of acetate of potash being	+ 13·3.

In the examples just given the salts formed remain in solution; the reactions in which precipitation occurs are better known, *e. g.*:

$$Na_2SO_4 + SrCl_2 = 2NaCl + SrSO_4 \text{ (precip.).}$$

There is no doubt here but that decomposition takes place; the heat is at 5° : +·41; at 16° : 0; at 25° : —·33; these results indicate clearly that the heat of the solutions does not determine the reaction. On the contrary, if all the bodies be anhydrous, heat is evolved (+7), a quantity which scarcely varies between 0° and 100° C.

There is no time to go further this evening; otherwise we might find ourselves entering on the application of heat measurements to the wide field of chemical equilibrium or to the study of organic chemistry. I have thought it best to confine myself to familiar reactions, but enough has been said, I think, to show the value of thermo chemistry not only in giving a satisfactory explanation of apparently abnormal reactions, but especially in indicating the points of connection and mutual relations between chemistry and the physical sciences.

A SIMPLE EQUATORIAL.

A BOARD, A, 8 in. long, 4 in. wide, and three-quarters in. thick. This may be placed on an ordinary camera-stand, or screwed to any convenient arrangement (mine was screwed in a south window until Venus's declination became too much north; it was afterwards placed on the tripod stand of a photographic camera).

On the board, A, a triangular piece of wood, B, 1 in. thick, cut carefully to an angle of 39 deg., the colatitude of the place; on to this a piece of wood, 1 in. thick and 4 in. in diameter, was fastened. In the center of this was screwed a bit of brass rod, D, three eighths of an inch in diameter, and projecting 2 in.

Another disk of wood, the same size, was turned, and a hole, three-quarters of an inch in diameter, carefully bored through its center.

A transverse hole was also bored to receive a bit of brass tube, E, to fit on the brass pin in the lower disk.

Through the upper disk, a brass tube, F, three-quarters in. in diameter and 4 in. long, was passed, to one end of which a brass collar was soldered to hold a small telescope. On the other end of the tube fitted a small counterpoise, G.

The telescope was a very small one, and might be replaced by a simple rod of wood, with sights attached to it. A pointer, H, was soldered on to this tube, so as to be parallel to the telescope. Another pointer, J, was soldered to the tube, E, parallel with the face of the upper disk.

On the upper disk was glued a card, graduated to degrees, and arranged so that when the telescope was horizontal the reading should be 39 deg.

A loose card revolves round the pin, D, which is divided into twenty-four hours, the hours being further divided to quarters and five minutes. The hours are marked from right to left for right ascension, also from left to right for time. This card can be fixed in any position by a drawing-pin, K.

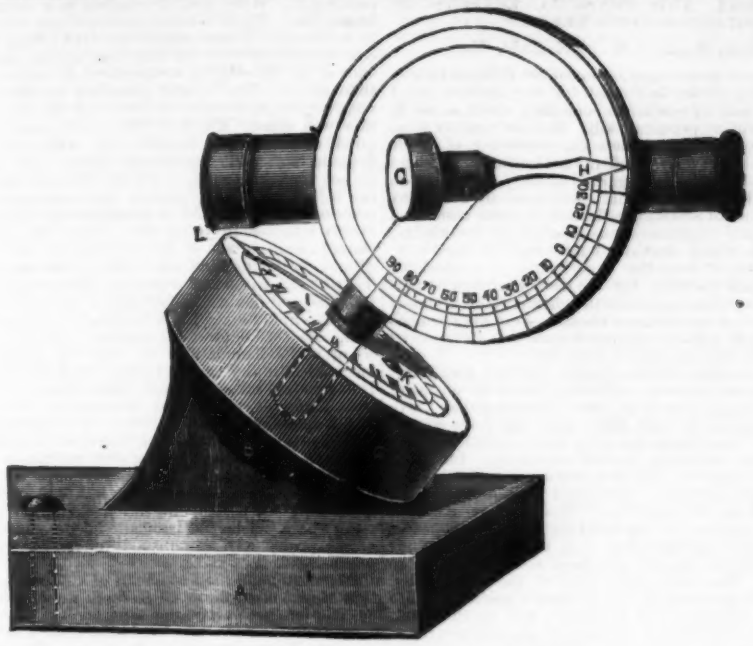
A line is marked on the lower disk at L, on the south side, to adjust the instrument by, which is best done with a watch, adding or subtracting the equation of time, so as to give the apparent time.

The instrument being set north and south, to find the star, set the sidereal time to the south line on the lower disk. Fix it in that position, place the pointer, L, to the star's R. A.; release the card and turn it so that the XXIV. hour-line is brought to the pointer; fix the card in that position. Set the other pointer to the star's declination, and turn the telescope so that the lower pointer shows the time on the inner circle of the R. A. card, when the star will be in the field of the telescope.

The instrument must be set up level, and the various parts require to be carefully turned; but the arrangement is so simple that any one with a lathe can make it in a few hours.

It is now many years since I first saw Venus by daylight. It was at one of our hill stations in India, and through the pure air she looked like a ball of marble suspended in the sky. The shading of the globe was perfect, the bright portion being about the shape of the moon when four days old. The darkest part did not extend quite to the edge on the dark side, but showed a thin line either of reflected or refracted light—which, I cannot say.

I had only a two inch telescope of Dollond's, with a power of about 25; but the freedom from any flare, and the perfect globe-like appearance, made it a much more beauti-



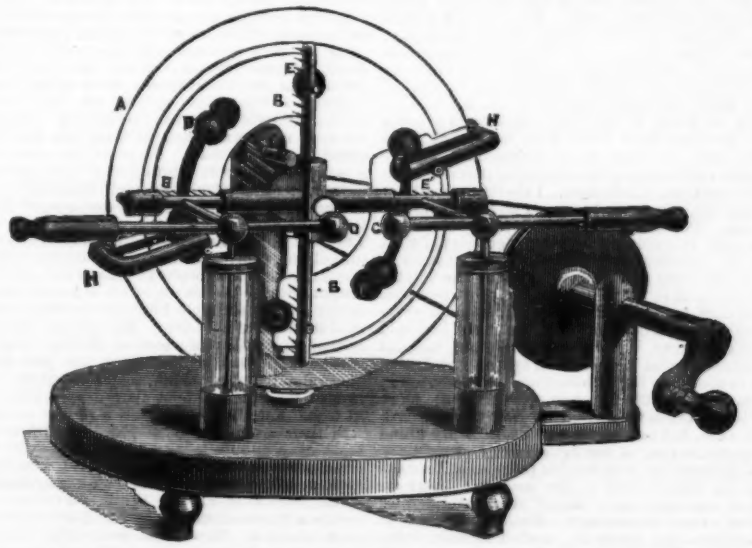
A SIMPLE EQUATORIAL.

ful object than it appears in our hazy atmosphere, and I have been rather disappointed with the observations I have made during the spring. E. LABANT.

P S.—I have just been trying the effect of the luminous p int to show the cross wires of the star-finder of my three-inch telescope, and it seems to answer well. A strip of paper was prepared with the paint, rolled into a cylinder, and slipped into the finder, just before the wires, after being exposed to the light of a bit of burning magnesium wire.—*English Mechanic.*

VOSS'S INDUCTION ELECTRICAL MACHINE.

THE modified Holtz machine, by Voss, possesses certain features rendering it of special value in this country, the most important of which is its independence of atmospheric conditions, as noted by the querist. The following particulars and drawing are taken from *Engineering*. The machine, in the fact that it is self-charging, requiring neither friction nor any outside initial charge to start it into action, nor is it necessary to bring the discharge terminals into contact, as in the Holtz machine, before commencing to work it, is perhaps the best in existence. On reference to the illustration it will be seen that the apparatus consists, like the Holtz machine, of two glass disks, unequal in diameter, of which the larger, A, is held in a fixed position, while the other is mounted upon a horizontal axis, and can, by means of multiplying gear be rotated at a high velocity. To the front face of the larger plate are attached two pairs of tin foil disks, F F, F^1 F^1, each pair being connected together by a strip of tin foil, and by a second strip to one of the two bent arms, H and H^1, by which they are connected to a light metallic brush directed toward the front face of the rotating plate. At the back of the fixed plate are pasted two paper coatings which correspond to what used to be called the paper "armatures" in the Holtz machine. To the face of the rotating plate are attached, at equal angular distances apart of 60°, and at a short distance from the circumference, six disks of tin foil (one of which is marked D in the figure), about an inch in diameter, corresponding in position and size with the tin foil disks upon the fixed plate, that is to say, if the disks, D, were numbered in rotation 1, 2, 3, 4, 5, and 6, those numbered 1 and 2 would, in a certain position of the rotating plate, correspond and be opposite to one connected pair of disks of the fixed plate; Nos. 4 and 5 would similarly correspond to the other pair, and Nos. 3 and 6 would have no disks on the fixed plate opposite to them. To each of the little tin foil disks, on the rotating plate and concentric with it, is attached a metallic button of the form of a plano-convex lens, and these buttons, in the revolution of the plate, pass under and are lightly touched by the metallic brushes, F F, which are held by the bent arms, H H^1, the brushes being so adjusted as only to touch the buttons and not to come in contact with the glass of the rotating plate to which they are attached. E' and E' are two horizontal collecting combs, insulated from one another by being attached to a horizontal bar of ebonite, but connected respectively to the two discharge terminals, C and G, in the front of the instrument by the horizontal bars shown in the figure, and the distance between these terminals can be varied at pleasure by sliding them through the balls which are attached to the inner coatings of the two cylindrical Leyden jars by which the charge is accumulated and the discharge intensified. E^1 is a vertical bar of brass carrying at each end a comb, directed toward the rotating plate, as well as a pair of metallic brushes, similar to F and F, and which also, in their turn, make momentary contact with the metallic buttons as they pass beneath them, and at a moment when they are not under the inductive influence of the metal disks of the fixed plate.



THE VOSS-HOLTZ ELECTRICAL MACHINE.

THE PRESSURE OF WIND.

IN a paper before the American Society of Civil Engineers, Mr. C. Shaler Smith gives the results of many years' observations of wind pressure and its effects. He has personally visited the tracks of destructive storms as soon as possible after their occurrence, for the purpose of determining the maximum force and the width of the path of the storm in every instance. The most violent storm in Mr. Smith's records was at East St. Louis, in 1871, when the wind overturned a locomotive, the maximum force developed in so doing being no less than 93 lb. per square foot. At St. Charles, in 1877, a jail was destroyed, the wind force required being 84·3 lb. per square foot. At Marshfield (Mo.), in 1880, a brick mansion was leveled, the force required being 58 lb. per square foot. Below these extraordinary pressures there were sundry cases of trains blown off rails, and bridges, etc., blown down by gales of wind of from 24 lb. to 31 lb. per square foot. Mr. Smith observes that in all his examples he has taken the minimum force required to do the observed damage, and has considered this as the maximum force of the wind, although, of course, it may have been much higher. Some of the hurricanes were very destructive, the one at Marshfield having cut down everything along a path of 46 miles long and 1,800 feet wide, killing 250 people. Mr. Smith has formed the conclusion that, notwithstanding these examples, 30 lb. per square foot is sufficient wind pressure to allow for in a working specification. As reasons for this conclusion, Mr. Smith expresses doubts as to whether a direct wind or gale ever exceeds this pressure. Whirlwinds may exceed it, but the width of the pathway of maximum effort in these is usually very narrow. Mr. Smith has only found one example, already quoted wherein the path of pressures over 30 lb. per square foot exceeded 60 feet wide. This pressure is in itself very unusual.

HYLOZOIC MATERIALISM.

Communicated by ROBERT LEWINS, M.D.

"Audi alteram partem."

THE two chief opponents by whom the Materialist is encountered are the negatively Agnostic *savant* * and the Christian divine, yet his theorem is simply a logical deduction from the fundamental principles of Science and Theology. Of science, which cannot logically assume two causes where one is sufficient, and must therefore deny that matter, being essentially active, needs to be "inspired" by a vital (or motor) principle; of theology, which, by postulating the existence of one Infinite *Omnipresent* Deity, in whom we "live and move and have our being," destroys at the very outset all distinction between body and soul, between God and the world. This last result of insight and reason is also the first dictate of instinct and nature, for every child, every savage, every simple and healthy human being is an unconscious Materialist. Yet although this Hylozoistic thesis is at once the expression of primitive feeling, the legitimate product of modern physics, and the scientific equivalent of ancient pantheism, it has been met, by learned and ignorant alike, with greater antagonism and anti-sympathy than have been accorded to any other theory of the universe. Though it is exemplified in their practical conduct, and implicitly recognized in their habits of thought and sentiment, they shrink with repugnance from its verbal exposition. Lately, however, it has forced itself upon public attention, and become an object of more calm and respectful criticism; and I here propose briefly to examine the principal objections with which it now has to deal, and to endeavor to estimate their force. They resolve themselves into these: 1st. That as man can know nothing beyond phenomena, he cannot absolutely deny the existence of an immaterial principle or soul animating the material body. And, 2d. That matter is in its essence inert, and, therefore, incapable of sensation and thought.

A little reflection will show that these two positions are mutually destructive, as the latter, which is purely metaphysical, claims for man not only a *positive* but a *negative* knowledge of noumena. Though he cannot predict how nature *will* behave under every possible combination of circumstances, he is yet capable of deciding how she will *not* behave. Except from his own sensations, he can learn nothing of the potencies of matter, yet he feels justified in assigning them a certain boundary, and declaring that they shall go thus far and no farther.

It is evident that we can obtain nothing from an idea which we have chosen to exclude from it, and if we arbitrarily limit the attributes of matter to extension and impenetrability there will be a large class of phenomena which lie without the sphere of our science and appear to be of supernatural or spiritual origin. But we are assured by the law of gravitation, as formulated by Newton and Laplace, that *energy* is as inseparable from every particle of matter as impenetrability itself, and this single addition to our idea supplies the place of all former animistic theories. The force which sustains and guides the orbs of heaven is not a distinct or external entity, but is immanent in every atom of their mass; and this "generalization from the Newtonian discovery cannot be restricted to 'brute' matter; it is equally applicable to the organic kingdom of nature, to plants, animals, and man. . . . The question of the *anima mundi* and *anima humana* (using the term in the sense of soul) is at bottom one and the same." †

In Mr. Barker's first article on "Life and its Basis," in the January number of the "*Journal of Science*," he justly remarks that "the belief that matter is, *per se*, *passive*, carries with it the belief in creative acts." It is not less true that the certainty that matter is, *per se*, *active*, renders all such beliefs—including the hypothesis of a distinct, immaterial, vivifying agency—both superfluous and absurd. Dualistic philosophy is deprived of its *raison d'être* by the removal of the sharp distinction between death and life, and by the theorem that both are diverse manifestations of one and the same energy. And this furnishes a reply to one of the objections mentioned at the beginning of this article, that, namely, which derives its force from the supposed impossibility of proving a negative. Total want of evidence is equivalent to *disproof*, and is practically so considered.

If we cannot deny the existence of the "soul," neither can we deny that of fairies, goblins, ghosts, or of the genii or "ruling angels," ‡ which were anciently believed to inhabit the planets and regulate their orbits. Yet it would scarcely be considered a wise exercise of scientific skepticism to suspend our judgment upon the truth of the "Arabian Nights." Nay, more; there is an immense mass of legal and other evidence in favor of the reality of witchcraft; but since we see that all its supposed effects may be produced by natural causes in the province of nosology, and since the supernatural explanation is out of harmony with our present habits of thought, we contemptuously dismiss a doctrine held by many generations of intelligent men, and never, except inferentially, disproved. We may, in the same manner, dismiss from serious consideration that invisible, intangible, indemonstrable entity, whose supposed function as an animating principle is fully discharged by the *vis insita* of matter alone.

The innate force which sustains the mechanism of the universe is surely sufficient to produce all the phenomena of animal and vegetable life, more complicated, but not more mysterious, than the motion of the earth round the sun or the falling of a stone to the ground. But it may be urged that, even taking into account this inherent energy, it is impossible to explain the powers of properties of organic by those of inorganic bodies. It may be said that mental and moral faculties "are not qualities of *matter*, not even of *living* matter, or they would be exhibited by plants and trees as well as animals." This is certainly true. There is nothing in a lump of earth, or even in a blade of *grass*, which can lead us to suppose that its constituent atoms will ever become part of a sentient organism.

But no argument can be drawn from this truism, unless we assume that the most easily ascertainable properties of any substance enable us to predict its behavior under all

* Of living *savants*—not to mention the great shades of Newton, Sir John Herschel, Brewster, and Faraday—who are supporters of Animism, may be mentioned the distinguished names of the Astronomer-Royal, Sir George Airey, the Lucasian Professor Stokes, Professor Adams, the discoverer of the planet Neptune, Mr. St. George Mivart, Professor Lionel Beale, Mr. Crookes, Mr. Wallace, etc.

† "Life and Mind on the Basis of Modern Medicine," by R. Lewins, M.D., reviewed in the *Journal of Scienc* of November last.

‡ See Pope's line in his "Essay on Man"—

"Let ruling angels from their spheres be hurl'd."

possible conditions. If this were so, the laws of one science would afford the complete *rationale* of every other, and we might have discovered the electric telegraph by means of the law of gravitation, and the composition of water by the principles of hydrostatics. But even directly related phenomena flatly contradict such an assumption. The cause refuses to account for the effect; the effect, to reveal the cause. This truth cannot be more strikingly illustrated than by the modern science of chemistry. From the individual properties of any two elements we can neither infer *a priori* nor explain *a posteriori* the result of their union.

In following the history of any chemical compound, we meet with phenomena not less wondrous and inexplicable than those of life and consciousness. I select a well-known example: Nitrogen and carbon, two inodorous and innoxious elements, unite to generate cyanogen an extremely poisonous gas, emitting a peculiar and penetrating odor, and producing in combination with oxygen, six isomeric compounds. One of them, cyanic acid, is a clear and strongly odorous liquid, which cauterizes the skin like red-hot iron, but in a few hours spontaneously solidifies into cyamelide, an opaque white solid, inodorous, and without acid qualities. Here it is evident that the constituent atoms no more possess the qualities of the compound than the molecules of the brain are individually endowed with the powers of judgment and reflection. Yet we do not find it necessary to assume the addition of a poisonous and odorous immaterial principle to the compound cyanogen, nor the exit of such an entity from cyanic acid when it is transformed into its isomer.

The science of chemistry may indeed fittingly illustrate that of biology, for the vital act itself is a purely chemical process. The life of man is identical with the life of a flame, being maintained by the oxidation or slow combustion (eremacausis) of organic tissue, at a temperature of 98° F. The oxygen which but a moment before formed part of the apparently non-vital atmosphere imparts vitality to the human frame, with which it is for a time incorporated. Being absorbed by the blood in its passage through the lungs, it is conveyed by heart and arteries to the network of infinitesimal capillaries, and from these to every atom of the living body, where it at once integrates and disintegrates, constructs and destroys. Life waxes or wanes as this non-incandescent fire burns with more or less activity and ceases with its extinction. Its feebleness in old age causes a corresponding decline in keenness of sense and intellect and in strength of character, for chemical conditions exercise the same control over moral and mental powers as over those which we have been accustomed to distinguish as purely physical. The function is uniform, the product diverse; for secretion, in all its forms, muscular motion and consciousness are but different results of the same invisible antecedent process, which alone sustains and vivifies "body, soul, and mind."

Thus the "cellular vitality" is really identical with that of the conscious brain, and the living corpuscle perfectly typifies the living organism of which it is a microscopic constituent. The relation is that of microcosm and macrocosm. This fact disposes at once of the distinction between that "corpuscular life" which is common to animals and plants and the "anima" which a consistent dualist must believe to reside in the lowest form of organized matter capable of sensation and volition.* The first dawn of consciousness is not more easy of explanation than the subtlest processes of human thought, and both must evidently be traced to the same origin, viz., to the inherent energy of matter, manifesting itself in more or less complex organisms. To regard sensation as proceeding from a super-material essence—a *donum divinum* superadded to organization—rather than from that physical development of nerve tissue with which it is invariably associated, is to prefer hypothesis to thesis, fable to fact.

It must be difficult, even for the most ardent dualist, to believe that, although the mental and moral faculties may appear to be irretrievably impaired by a serious injury to the cerebral hemisphere, the soul yet remains intact, and will be restored to more than pristine vigor by the final destruction of that corporeal mechanism whose *partial* disintegration has already paralyzed will, emotion, and thought.

Every medical practitioner acts on the material theory of mind, just as every evolutionist implicitly asserts it. The Darwinian and any other modern theory of evolution *must* be essentially materialistic, since the continuity of the chain of life, from yeast-cell to man, leaves no point where we can assume the intervention of a spiritual entity, modifying or "inspiring" the physical organisms. That the bee has a soul denied to the flower on which it feeds, that man has a spirit to which his dog can lay no claim, cannot logically enter into the "scientific imagination" of our age.

I must here venture to protest against Mr. Barker's assumption that the "initiation of the living state in the lifeless, whether it has formerly been alive or not, must be due to the action of an unseen higher power." As at present observable, such initiation is a process controlled or regulated by ordinary material conditions, though these are too complex to be formulated into definite laws. In what manner the "*vis insita*" of matter may have manifested itself under palæontological conditions it is impossible to determine. It is likewise impossible to affirm or deny the existence of a supreme intelligence or pantheos, but such a conception is plainly inconsistent with dualism, and can only be founded on the sublime hylozoistic conception of the universe. Man has created God in his own image, but he cannot conceive his deity to be all in all and truly omnipresent until he has recognized the sentient and non-sentient cosmos as an indivisible and homogeneous unity.—*C. N., in Journal of Science.*

* The so-called process of "assimilation" carried out by plants is, of course, the direct reverse of animal respiration, yet in both cases vitality is sustained by a chemical process; and it must not be forgotten that vegetables also respire, and that, although they absorb oxygen in relatively small quantities, it is not less necessary to their life than to that of animals. Perhaps I may be excused for referring here to a statement in Mr Barker's article which I cannot but suppose must have been inserted by some inadvertence. He asserts that, while animal forms of protoplasm comprise all four of the elements—carbon, hydrogen oxygen, and nitrogen—"vegetables, with a few exceptions, contain only the first three." It is a fact well known, not only to the botanical chemist, but to the practical agriculturist, that vegetable protoplasm *invariably* contains nitrogen, and that crops will not thrive if the soil be deficient in nitrogenous substances.

THEORY OF THERMO ELECTRIC MOTIVE FORCES.

By M. PILLEUR.

THE author suggests that the motor force of a thermo-electric element is proportional to the difference of the coefficients of thermic conductibility, under the influence of the temperature of the metals composing this couple, and to the difference of temperature of the point where the metals are soldered together and of the rest of the circuit.—*Les Mondes.*

THE CHEMICAL AND PHYSICAL EFFECTS OF FILLINGS UPON TEETH.*

By CHARLES MAYR, A.M., Springfield, Mass.

THE task I have undertaken is almost too difficult for me. My practical experience in dentistry is very limited, yet I am to say to a body of specialists something about an art so greatly dependent on practical skill. But our century is no longer a century of wild, planless experimenting, of crude empirical knowledge. Everywhere the theories of sciences are invading domains so far regarded as only dependent on mechanical skill. Many special cases come up every day where one minute of scientific reflection is worth more than years of practical experience unsupported by knowledge. The science on which dentistry finally rests is chemistry; not the chemistry of beautiful experiments, of explosions, strong colors and reactions, but the most complicated part of the whole enormous science—the chemistry of albumen or physiology; and on this issue chemists—not the chemists of common people, who are not much more than drug-clerks or stone-diggers—have a word in dentistry.

Some chemists shirk all investigation into this most interesting but almost infinitely difficult branch of chemical science by the vague term *vital force*. They say that "live tissues are produced by vital force, that vital force acts in the body," etc; they think this vital force something inaccessible to laws, something beyond chemistry. Indeed, a lazy school-boy could not invent a better excuse for his not wanting to learn any more. How glad he would be if his teacher should say, for instance: "Now we have come in algebra to the equations of the third degree, they cannot be solved any more, and therefore you have finished your work." He believes it; and yet there are people who go much further. The same holds good of the term "vital force." People get tired of going further ahead, and are putting up for themselves an imaginary goal by this term. Yet, fortunately, the highest teachers of all countries never get weary of investigation; onward they move, and they now only use the term "vital force" instead of "resultant of mechanical and molecular forces acting in combination with albumen." The effects of this peculiar resultant are termed "vital effects" or "life;" be it now the life of the individual, or the cell, or the protoplasma-fiber. The great problem of physiology is to resolve this resultant into its components, and so to trace back the effects to their final and easier intelligible causes. It has been done with light, with sound, with heat to a large extent, with electricity and magnetism to a small extent, and in the coarser mechanical phenomena of astronomy and mechanics almost to perfection. It will be done with "vital force," taken in the sense in which I understand it. But we have hardly commenced to study the chemistry of albumen. Chemistry, this really divine science, is not yet one hundred years old, and the chemistry of albumen is hardly born. We know about the chemical constitution of albumen just about what Lavoisier knew some ninety years ago about sulphuric acid. All we know are a few approximate analyses and gross reactions like coagulating, etc., but no constitution is yet known, no formula assignable to the albuminous substances; we have not yet been able to explain the chemical effect of one albuminous substance upon another. If the adepts know so little about it, what wonder that people who are not adepts in chemistry ascribe chemical reactions to imaginary supernatural forces that exist as little as witches, sorcerers, and the host of other impossibilities invented by ignorance!

I would not give to you these long introductory considerations if they were not to show how much still remains to be done, and to enable you to excuse me for the little new I can give here. It will require the Hercules power of a Newton or Kepler to bring light into this night of the chemistry of albumen.

If the chemistry of albumen—protoplasma—is still so little known, we hardly can expect that all the processes going on in a tooth should be better known. We scarcely realize how complex a structure a tooth is, considered chemically. There are at least thirty organic and inorganic compounds acting upon each other, mechanical contrivances in the tooth like canaliculi, pulp, etc., interfering with the mere chemical actions; so the more we know about a tooth, the less we know of it. All we know is, that every process in a tooth is chemical or mechanical—a third does not exist, since light, electricity, etc., all have to be grouped among the latter. Its origin and its decay are chemical processes, explainable by the reactions of albumen. I therefore shall not enter at all upon the causes of decay. I have to consider the facts as given. There is no doubt with me that one day science will be able to explain everything connected with the chemistry of albumen, and the effects and causes of diseases will be calculated just as exactly as the movements of the stars, of heat and light. The scientist, who, perhaps, will smile at our dark age, will calculate that, say four years and three months after a certain fever, the right bicuspid would commence to decay, if, some months before, that and that albuminous compound had not been taken. The dentist will then have to use more logarithms than instruments.

To-day we stand before the fact that, generally, the most skilled dentist is powerless to prevent the formation of cavities. He has to cure, but cannot prevent disease. By filling the cavity properly he can, as the facts show, check the onward course of destruction; and for this purpose he uses one or the other of the fillings now in the market. There are four kinds—gold, amalgam, basic salts of zinc, gutta percha, omitting some of minor importance. Each filling acts in three ways—mechanically, thermally, and chemically, sometimes by electricity. The effects will, further, be very different in young teeth and old teeth, "live" and "dead" teeth, etc. I shall not enter into the definition of live and dead tissue. I should like only to draw your attention to the histological difference between young and old teeth. Not that the grossly chemical composition is so very different, but there is a difference in the way in which it is distributed. In young teeth the protoplasma substances in the alveoles, in the pulp, and in the dentine itself, are still building up; the lime salts are not yet distributed, as in old teeth; the moisture is greater, and the circulation quicker. As circulation is the essential feature of what we call live tissues, we are justified in saying that young teeth have more life. In old teeth the building-up has ceased, the protoplasma-fibers withdraw from the periphery where lime salts are accumulating, the pulp itself is slowly disappearing, the tooth becomes harder. Now this difference in teeth as to age, development, personal conditions, etc., is the cause of the differences of the action of the same fillings in different teeth.

Let us consider the fillings in the three directions—mechanically, thermally, and chemically. The mechanical effect of a filling is chiefly produced during the process of packing it. With gold it consists in a relatively violent hammering. There is no doubt to me that this violence may be injurious. We are permitted to infer from a similar process in other parts of our body that any mechanical disturbance of the histological arrangement of organs will produce these effects. The injured parts will be fully restored by a relatively short process, or they will die *i. e.*, the circulation will cease. The first effect will occur in parts with quick circulation, in muscles, etc., while the second effect is liable to occur in organs with already slow circulation. I do not doubt that many a failure of a gold filling is due to the injury the tooth-structure has experienced during the process of packing. As a disturbance of the circulation is chiefly injurious in young teeth from the above reasons, I should ascribe a part of the difference of the effect of gold-fillings in young and old teeth to the mechanical insult. That a tooth can be the seat of an inflammation seems to me to be beyond doubt. Inflammation is defined as a disturbance of circulation with a tendency to sloughing or secretion. As the slightest mechanical injury of a muscle may set up an "inflammation," it might be inconsistent to say mechanical injury cannot produce such an effect in a tooth. Inflammation takes the most varied forms; a cold, a boil, an iritis, a pimple, pneumonia, rheumatism, are special forms of inflammation. Now the effect of inflammation in a tooth will be—as everywhere—first, increased sensibility, then increased secretion, finally either slow restoration of the former condition, or sloughing and destruction. We are fully able to observe the first stage and the last in every tooth. Caries is nothing but a slow ulceration similar to chronic ulcers everywhere. That mechanical violence can cause it, seems to me pretty well established by the analogy with other organs.

Among the mechanical effects of a filling must be counted that of excluding liquids. Though we do not know the exact relation, yet observation is in favor of the view that the buccal liquids have to be excluded from a cavity as well as possible, if there should not be danger. The idea that a gold filling excludes moisture absolutely, seems to me untenable. Even the most solidly-packed gold never is solid gold. Small cracks are everywhere. The best filling I read of had a specific weight of 18; as pure gold has a specific weight of 19·36, it follows that more than 7 per cent. were cracks. Gold certainly does not exclude the moisture as well as any of the other fillings. The mechanical effects of the other fillings while being packed are far less than those of gold, the use of amalgam and oxy-salts of zinc having almost no mechanical effect to speak of, while gutta percha might sometimes be heated too high when put in the tooth. All these fillings exclude moisture better than gold.

The next effect of a filling is its thermal effect. We all know how sensitive organic tissues are to changes of temperature. I do not only speak of the organs generally protected against sudden changes, but even the organs exposed to all changes of weather since the existence of man, still show a most unpleasant sensitiveness to thermal changes. Take, for example, the mucous membrane of the nose. For thousands of years it has been exposed to all kinds of weather, and still it is most sensitive to changes. The fact is, that ten degrees difference may produce a cold, which becomes chronic, destroys the os petrosum, the meninges, the brain, the person! How complex is here the connection between ten degrees change of temperature and the death of a person. I know such a case. Can we suppose that teeth are less liable to become diseased in consequence of changes of temperature? Certainly not, and I have some facts on my side. In countries where people are not in the habit of drinking hot and cold water—tea and ice-water—at their meals, diseases of the teeth are far less frequent than where they do so. We have Italy, Russia, China, on one side—America, England, and Switzerland, on the other.

I shall not dwell too long on this point; let us only consider what fillings do in this direction. By a good heat-conducting filling we can carry changes of temperature within the tooth which are most sudden and violent. In sound teeth it takes at least five minutes for a change of only twenty degrees to take place, and then probably never throughout its whole mass. By a filling like gold, which conducts two-thirds as well as the best conducting metal known—silver—we can bring the changes to tissues not only not accustomed to them, but even not at all prepared by slow increase. In nearly all such cases the change is sudden and great. Suppose a cavity of a depth of five millimeters (one-fifth of an inch) filled with gold. The person has been eating, say, an oyster stew of 130 degs. Fah.—the common temperature we like in such kind of broth. The gold filling carried the difference between the temperature of the broth and that of the mouth (130—98=32 degs. Fah.) almost undiminished to the bottom of the cavity. (The diminution can be calculated; it is about 2 degs. Fah.) The cavity around the gold filling has assumed the temperature of 128 degs. Fah. Now the person feels warm, and of course (?) drinks ice-water of 32 degs Fah. Taking into consideration the specific heat of the gold filling, it will assume about 40 degs. Fah., which it carries with a diminution of the cold of about four degrees (that is, as if it was 44 degs. Fah.) into the interior of the cavity. The cavity will then assume 44 degs. Fah., the difference within one-tenth of a minute being 128—44=84 degs. Fahrenheit!—a change which in any organ whatever would produce a most violent inflammation, if such an organ should not be well accustomed to it, like the hands. Few persons would even escape a rheumatism in case the hand should be exposed to such changes. Now, what does such a derangement mean in a tooth? It means disease of the protoplasma-fibers, interruption of the circulation—necrosis; precisely what dentists observe. Young teeth, which are still more dependent on circulation, will be affected more easily than old ones, where the fibers are fewer, and which resemble, in some respects, an inorganic structure. As this disease takes place all around a gold filling, we might expect a zone of white necrotic dentine under such fillings.

Amalgam fillings have an effect similar to gold fillings, yet in far less degree, owing to their inferiority in heat-conducting power. For the comparison, I give specific heat and conducting-power of the common fillings, from the most reliable observations and calculations:

	Specific Heat. Water=1.	Heat-conducting Power. Silver=1.
Silver	0·057	1·00
Gold	0·032	0·60
Tin	0·056	0·12
Platinum	0·031	0·10
Amalgam	0·050	about 0·09
Mercury	0·031	0·03
Oxy-salts	0·130	0·008
Gutta percha	0·500	0·000001
Dentine (natural)	0·400	0·006

* Read before the Connecticut Valley Dental Society.

We therefore see that the thermal effect of a filling not only depends on the heat-conducting power, but also on its specific heat; so the more the latter approaches that of a tooth, the less is it liable to produce sudden changes In this respect amalgam is almost 100 per cent. superior to gold. Specific heat will manifest itself by the speed of changes, while the heat conducting power influences the intensity. The difference in the above example of a gold filling was 84 degs. Fah., while under the same circumstance amalgam would only have produced—

First heating, 104 degs. } Difference, 46 degs.;
Afterward cooling, 58 degs. }

that is, the effect is only one-half, at the most, of that of gold. As to the relative speed of changes, it may be said that gold produces this change in one-tenth of a minute, amalgam in one-quarter of a minute. These figures may vary in different persons, locations of cavities, size and form of cavities, yet the fact will remain that, other things being equal, amalgam fillings will produce only one-half the change of temperature of gold fillings in twice the time, therefore with far less insult for the tissue. I think that dentists have observed that the cavity under an amalgam is —almost without exception—sound, and formed by live tissue. We should consider very well the thermal insult of gold fillings in young teeth. Oxy-salts of zinc resemble dentine somewhat in their specific heat and conductive power. Calculation, as in the above example of a cavity, would give a difference of about 2 degs. Fah., which is almost insignificant. They may, in this respect, be considered identical with dentine.

Gutta percha might rather have an opposite effect. The cavity around it will be kept at a more uniform temperature than if it was dentine, yet the difference would be only about ⅛ deg. Fah. in the above example. I might enter into the effects of fillings when being used, as to their distributing and transmitting the pressure of mastication evenly, but it would lead too far.

A third effect of fillings might be termed chemical. A filling may affect the substance of the teeth by affinities, or might protect it by neutralizing the acid around it. In this respect gold is completely indifferent; it is not acted on by, nor does it act on, any liquid in the mouth. The filling is excellent, yet this excellency of the filling has its defect. It does not protect the tooth as oxy-salts do. Small cracks between tooth and filling are not filled up with oxidation and sulphurization products. Tooth and filling are never cemented together. This inactivity of gold, therefore, is very dangerous for the tooth, though not for the filling. But what do we wish to preserve?

It is quite different with amalgam. Though acted on but slowly by the liquids of the mouth, yet it is acted on sufficiently to fill up small cracks between tooth and filling and to become cemented to the tooth. The filling becomes tight by the same principle by which steam-boilers are made tight. The boiler-makers make the seams tight by oxidation, which they foster by certain mixtures. The rust fills up small cracks, so that a boiler of iron is far easier to make than one of silver or gold. With gold, in fact, it would almost be impossible to make a boiler, for this reason alone—because no hammering can fill up cracks as perfectly as oxidation.

Yet amalgams have another disadvantage—their shrinkage. The process of hardening of amalgams is one of crystallization, due to the formation of chemical combination. We know but few cases of such combination where the volume of the combination is the sum of the volumes of the elements. Generally contraction follows, rarely expansion. Tin and mercury form the following compounds:

Sn_3Hg	with 34	per cent.	mercury.
Sn_2Hg	" 46	"	"
$SnHg$	" 65	"	"
Sn_3Hg	" 75	"	"

The only compound without shrinkage is SnHg. Sn_3HG shrinks about 8 per cent. Theory gives, therefore, quickly the proportions of a good amalgam, supplanting years of planless trying. More than 75 per cent. of mercury cannot be combined chemically with tin. The excess will disappear in time, and cause a very great shrinkage. Similarly, with silver and mercury; many compounds are known with 64 per cent. Hg, 72 per cent. Hg, etc. All silver amalgams are very soft, shrink considerably, and lose relatively, easily, their mercury. Still less stable are compounds of gold and platinum and mercury. The mercury evaporates from platinum as if no combination had taken place. The causes of shrinkage are therefore three: Crystallization, disappearance of mercury in excess, disappearance of "combined" mercury. I am at a loss to say why some amalgam-makers put gold or platinum in their amalgams, if it is not to give to their amalgams some nice taking name—gold amalgam How a certain mixture will work is very difficult to tell beforehand, yet we may always get an approximation to the truth. I will not deal here with the other objection—that mercury might "get into the system" from an amalgam—it would show too much esteem for certain medical superstitions

The oxy-salts of zinc act chemically. While being put into the tooth the chloride of zinc or phosphate of alumina will decompose a small quantity of lime salts; but this action will cease as soon as the filling has hardened—that is, the chemical union, $ZnO+ZnCl_2=Zn_2OCl_2$, has taken place, and the very small quantity of carbonic acid, etc., formed is very easily absorbed and the tooth not further molested, nay, it is now even actively protected. These fillings are more easily decomposed by acids than the tooth substance; hence they neutralize the acid near the tooth and thereby protect the tooth. As a necessity, they will disappear, and that is what the average patient alone observes. He cares less about disappearance of the tooth than of a filling! Much remains to be done everywhere in the line of education and fostering the work of doing one's own thinking.

As oxy-phosphates resist far more—I made experiments on this point—than oxy-chlorides, they are to be preferred. The chemical effect of gutta percha might be an unknown physiological one, yet grossly chemical, it is inactive, though resisting less the liquids in the mouth than oxy-salts, without protecting the tooth.

Fillings sometimes produce phenomena of electricity I do not mean anything in the line of the so-called new departure, which displays all the errors possible as far as electricity is concerned. I mean contact or statical electricity, affecting nothing but the nerves, but often most markedly. Also in this line gold fillings are the worst, because of the great potentiality of gold in electrical combination. Oxychlorides and gutta percha have no effect at all, and amalgam very little. By irritating the nerve constantly, as in a case of Dr. Stockwell's, where an amalgam filling was capped with gold, they may produce persistent neuralgia, and perhaps, physiologically, produce changes in the nutrition of a tooth. Yet, as the unpleasantness is so very great, we will avoid it. It is unnecessary to say that only the contact of two *metals* produces such electricity, like a gold filling and a spoon or fork, etc.

I would sum up my conclusions thus: Gold is *the worst filling* in most cases. It should be used chiefly in old teeth. Amalgams should be used everywhere where the patient's fancies, notions, and similar kinds of bias do not prevent it; while oxy-salts of zinc are the fillings for frail teeth, for capping pulps, etc. Yet let dentists never forget that none of them is the ideal filling. This is not a metal, it is a silicate, translucent like the tooth, not acted on by acids, capable of a high finish—in short, a filling resembling the tooth-substance as closely as possible. Let not the foggy dogma of the superiority of gold act on progress as the old mediæval superstitions acted on astronomy, physiology, and zoology for so long a time. Because gold is so much life's only aim with most people, they forget that gold has no intrinsic claim to its superiority except long-sanctioned custom; that chemically it is far inferior to platinum, mechanically to iron, and still more to steel; that its color is not finer than that of brass. Unclear alchemistic ideas are still active everywhere. They are the worst obstacle to clear logical thoughts. The dentist has to educate people, yet first he himself must not be biased by the same scientific superstitions. Let him never get tired of searching for something better. We shall never reach perfection, and the field of researches is as boundless as space and time. So far the views of the theory —only the practical dentist can judge how far they are in accordance with his experience.

RHEUMATISM.

By M. P. GREENSWORD, M.D., Poughkeepsie, N. Y.

I WILL give my experience in treating acute and chronic rheumatism and sciatica.

Being a native of the island of Jamaica, W. I., where, as in all tropical countries, rheumatism prevails to a far greater extent than in temperate climes, sometimes attacking the muscles of the back as well as all the joints of the body, making the whole body so rigid as to remind you very strongly of tetanus, and called by the natives back ache, fever, or dandy fever, and where chronic rheumatism, in its various forms, very often cannot be cured without removing the patient to a more temperate clime; and having treated with very great success a great number of these diseases, my experience for the past 23 years must be of some use to my younger brethren in the profession.

I always feel almost certain when I get a case of rheumatism from a homœopathic physician that I will cure it, because, if he is a strict homœopath, I know he can accomplish but very little in rheumatism or in any severe disease.

I was amused, some years ago, when two homœopathic physicians took a case of rheumatism, in a boy two years of age, off my hands. One remarked to the other that it would be unnecessary to attempt to stop the pain. I thought, if you do not succeed in stopping the pain, the disease will attack the heart and brain and destroy life. And as they did not try to remove or even to relieve the pain, either with internal or external remedies, of course the patient died in a few days from metastasis of the disease to the heart and brain.

In treating either acute or chronic rheumatism I always avoid doing anything to weaken the patient, and I am very careful to either prevent or remove constipation of the bowels. Sometimes I find lemonade useful, at other times it is injurious.

I have sometimes met with old persons troubled with sciatica that I cured very easily by the use of a strong tincture of prickly ash bark. I have supposed that such cases were produced by the sluggishness of the blood, which moved so slowly in the flow vessels that congestion and consequent pressure upon the nerves was the cause of the pain. When I began treating rheumatism, I adopted the alkaline theory and used Rochelle salt very freely, giving it in tablespoonful doses to adults three times a day for chronic cases, and sometimes every two hours for acute cases. By this treatment I often cured acute cases of articular rheumatism in one week, and chronic rheumatism and sciatica in three months.

I have seldom found outward applications of much value in chronic rheumatism, but in acute cases I have sometimes used hot water, say two quarts, in which was dissolved four ounces of bicarb. soda, and also an ointment made of the leaves of the datura stramonium. In only a few cases were these applications of much value, and even then they were merely palliative. About sixteen years ago I commenced to use the following prescription, which has cured hundreds of terrible cases of acute and chronic rheumatism and sciatica. Among this number was one of sciatica of 31 years' standing in a man of 76. Another also of sciatica of 20 years' standing in a man of 45, three of ten and several of five years' standing of the same kind of rheumatism.

℞. Wine tinct. colchicum from the seeds,
and fld. ext. black cohosh ..... ää ʒ j.
Whisky and aqua..... ää ℥ ij. M.

A teaspoonful fifteen minutes before each meal in chronic and every two hours in acute cases for adults.

I have lately used the salicylic acid as follows, with great success:

℞. Pulv. socotrine aloes..... ʒ j.
Salicylic acid ..... ʒ ij.
Whisky ..... ℥ j.
Aqua ..... f℥ v. M.

A teaspoonful fifteen minutes before each meal in chronic and every two hours in acute cases for adults.

With this prescription I cured a lady of 87 of sciatica of twenty years' duration in three months.—*Medical Summary.*

MODIFICATION OF ANÆSTHETIC METHODS.

THE *Revue de Chirurgie et Arch. Méd. Belge* observes that Messrs. O. de Stefanis and Vachetta, convinced of the dangers attending the use of anæsthetics—statistics showing that with chloroform there appeared one death in 2,873 cases, with ether one in 23,204, while bichloride of ethylene showed one death in 5,000 cases—propose a modification, which has already given them excellent results, both upon men and animals.

It was suggested to them by this consideration; that death being caused by cerebral anæmia or cardiac paralysis, anything that could induce a congestion of the nerve centers and excite the heart would help in controlling the noxious effects of the anæsthetic agent, without diminishing insensibility. For this purpose they make use of alcoholics; we shall not repeat here their experiments on dogs and rabbits; it is more interesting to note the method recommended to bring on inebriety in the subjects to be anæsthetized.

In place of prescribing a strict fast, they advise patients to eat a light breakfast of crackers or bread, and according to age, sex, strength, and the habits of each one, to drink a certain quantity of some light wine, like claret. This quantity may vary from 100 to 200 grammes. (*f.* ʒ xxv.–*f.* ʒ l.) Those accustomed to alcohol may besides take a little brandy. When the heart is found to be sufficiently excited, the inhalation of ether or chloroform may be proceeded with.

Experience proves that under these conditions complete anæsthesia is obtained in a few minutes, by the use of from five to ten grammes (m 75 to 150) of the anæsthetic agent.

Judging from their first experiments, the authors believe themselves warranted in drawing the following conclusions:

When a dog is prepared for anæsthesia by the aid of Marsala wine, he is less sensitive to the effects of ether or chloroform, but the dangers inherent to anæsthesia are reduced. If the animal is inebriated, insensibility and muscular relaxation are longer in showing themselves.

If anæsthesia is repeated at short intervals, the subjects become less liable to its effects. Alcoholic intoxication, both in man and in animals, does away with all danger arising from cardiac paralysis, or cyanosis due to vasomotor palsy; no emesis has ever been noticed.

A man slightly under the effects of alcohol yields more readily to the influence of an anæsthetic; a lesser quantity is required to produce sleep.

In no case has sleep been followed by such marked secondary phenomena, like vomiting, prolonged somnolency, and failing temperature, as happen with patients who have been put to sleep by the ordinary method.

ON HARVESTING MACHINERY.*

By MR. E. SAMUELSON, Banbury.

IN a paper read before the Manchester meeting of this Institution by Mr. W. R. Bousfield, the operations of agriculture were divided into four chief divisions, as follows:

(1.) Preparation of the land. (2.) Sowing of the seed. (3.) Harvesting of the crops. (4.) Preparation of the crops for consumption.

The writer proposes to take for his subject the third division, and, without going into the history of the question, to discuss some of those machines which are in practical use in the country at the present date.

Harvesting machines may be divided into two main classes, as follows:

(1.) Those in use for cutting and gathering our hay crops, whether of natural or of artificial grasses.

(2.) Those designed for the harvesting of corn crops.

The first division may be subdivided into three classes:

(*a.*) Those machines used for cutting down the standing grass; or mowing machines.

(*b.*) Those used for spreading the cut grass, in order to expose it to the influence of the sun and wind; or hay-makers.

(*c.*) Those which are used for gathering the spread crop; or horse rakes.

As time will not permit of the latter two subdivisions being included in this paper, the writer intends to confine himself on this occasion to the first, or mowing machines.

Mowing Machines.—A mowing machine consists of three main parts: (1.) The cutting apparatus, which travels close to the ground, generally carried on a wheel at each end; (2.) A frame containing the gearing which puts the cutting apparatus in motion; (3.) The two main wheels, which support the frame, and by their adhesion furnish the motive power to the gearing.

The pole or shaft, by which the horses are attached to the machine, is generally fixed by means of a "pole bracket" to the axle of the traveling wheels, and turns freely upon that axle; in many cases the draught is taken direct from the main axle, but in some it is taken partly from the main frame itself.

Cutting Apparatus.—The transmission of the motion to the cutting apparatus is effected generally in one or two ways. In the first case one or both of the main wheels have an internal ring of teeth, into which gear one or a pair of pinions, which are carried on a first motion shaft, and transmit their motion to it by means of ratchet boxes and pawls. They thus convey motion to the cutting apparatus only when the machine is moving forward, the wheels revolving independently when the machine is being turned or moved backwards.

On the first motion shaft runs loose a bevel wheel, which gears into a bevel pinion, keyed on to another shaft at right angles to the first. To the other end of the latter shaft is fixed a crank wheel, and a connecting rod is used to couple this crank with the reciprocating knife. Clutch gear is generally used for throwing the bevel wheel in and out of gear with the pinion.

In the second method of obtaining the requisite motion for the knife, the traveling wheels transmit their forward motion to the main axle, through ratchet boxes and pawls, and thence to such a train of gearing as is necessary to obtain the proper speed for the knife. This class of machine is used chiefly in cutting artificial grasses, which are not so difficult to deal with as natural meadow grass, and also where the crops are light. The chief advantage of this method of driving is that it enables the whole of the gearing to be completely boxed or covered in, and so protected from dirt; on the other hand, such machines are much heavier in draught, owing to the point of application of the power being so much nearer to the center of the axle. The cutting apparatus consists of a flat bar (made in America of cold rolled iron, but in England of steel), to which are attached a set of toothed projections or fingers, having a slot or space cut in them; and in this slot the knife or sickle is caused to reciprocate.

These fingers are made in various forms, either of the solid or open pattern. In the former the sickle or knife runs upon the cutter-bar, while in the latter it runs upon a kind of open framework, formed by the fingers themselves, and so allows the dirt and short pieces of grass, moss, etc., to be worked out by the movement of the knife. Fingers are made of chilled cast-iron, malleable cast-iron with steel plates riveted on for cutting edges, wrought-iron with riveted steel plates, and a combination of welded iron and steel. The cast-iron fingers have almost gone out of date, having been superseded by the latter forms.

In the second and third varieties, the steel plate is riveted on to the bottom face of the slot; the objection, however, to

* Paper read at a meeting of the Institution of Mechanical Engineers.

this form is the liability of the plate to become loose. With the welded steel and iron fingers, the steel plate, instead of being riveted, is welded on to the wrought-iron, in some cases both on to the top and the bottom of the slot. Another method is that employed by Messrs. Samuelson & Co., where the fingers are piled or built up in the following manner: A square bar of wrought-iron is taken, and another small piece of iron, about 4 in. in length, is welded on at one end, and drawn down to a point, forming a V-shaped pile. Between the ends of these two pieces is laid a short piece of round iron at right angles, and one end of the jaw is closed over it; and then upon each side of the pointed end is welded a small steel plate. The pile, as thus formed, is brought up to a welding heat, and placed under a stamp in a pair of dies, and the necessary shape is thus given to the finger. When it leaves the dies it goes to a pair of fraying tools, and from thence to a circular saw, where the slot is cut within which the sickle works; finally it is fitted to the beam, and hardened.

By this process of manufacture a hard-cutting edge is secured, while a soft core is maintained in the center, and the core, being the first to wear, always leaves a flat surface for the sections to work upon. The grain of the iron runs in the direction of the point in the main body of the finger, and at right angles to this in the cross bar, and this insures the strain being taken up by the iron in the most advantageous manner.

The knife or sickle is composed of a number of steel triangular sections riveted on to an iron or steel bar or back. These steel sections are hardened in one or other of two ways: either uniformly throughout, and then tempered to such a degree as will admit of their being sharpened by a file, or else in such a manner as to leave a harder-cutting edge of about $\frac{3}{8}$ in. along each side, the rest of the section being soft; in this case a grindstone is necessary to sharpen them. At each end of the finger, or cutter-bar, is fixed a shoe, carrying a small wheel, which can be adjusted so as to raise or lower the cutter-bar from the ground.

The method of attaching the cutter-bar to the main frame is either by a radial joint, or through a wrought-iron link. On this latter, or the "Buckeye" plan, means are provided for altering the angle of the fingers, or tipping the points downward in order to creep under laid grass; but this is of doubtful utility, as it entails complication, and is liable to cause the fingers and knife to become choked with dirt, and so stop the machine. The finger bar, being in either case attached to the main frame by a hinged connection, is capable of being raised and held in a vertical position, for the purpose of traveling more easily along roadways, etc.

It is sometimes necessary to raise the beam off the ground horizontally when at work, in order to pass over any obstruction; this is done by the driver from his seat, by means of a lifting handle and a quadrant, over which passes a chain, a system of levers being used in order to sustain the weight of the beam. When the machine has been once round the field and starts again, a clear track or path is necessary for the horse, which walks round nearest to the standing crop, and for the traveling wheels; and this is provided for by hinging a trackboard to the off-side shoe inclined inwards toward the main wheels. On this board is fixed a round stick still more inclined to the near side, so that, as the grass is cut and passing along the board, the stick turns it over and forms a swathe. The wheels and horses pass on each side of this in making the following cut.

The tendency of all machines which have the cutter-bar placed in front of the main axle, is for the beam to exert a pressure upon the ground, this being due to the direction of the power as transmitted by the traveling wheels, and also to the holding down of the beam by the grass. This downward pressure must be balanced in a well-designed machine, and various methods are employed for this purpose. These methods enable the beam to float, as it were, over the ground, but without rising from its work. On steep ridge and furrow this is especially desirable, and either such arrangements must be employed, or a third wheel must be attached to the front of the frame by means of a short pole, which lifts the beam as the machine rises up the ridge.

General Features of Design.—While lightness of construction is desirable, strength must not be sacrificed to this, because it is a very serious matter for the farmer if some part of the machinery gives way under a sudden strain, to which this class of machine is particularly liable, such strains arising from obstructions on the surface of the ground, or from the knife and fingers being blunt or becoming clogged or choked up. Again, the frame and gearing must not come within about 6 in. of the ground, otherwise it will disturb the cut swathe over which it is passing, and be liable to pick up some of the cut grass; for which reason it is also usual to cover in, as completely as possible, all rotating parts.

The width between the traveling wheels is generally about 3 ft., so as to run on each side of the swathe, and the average diameter about 2 ft. 4 in. to 2 ft. 6 in. The width of the thread is about 4 in., and it is generally studded at intervals with projecting ribs or stucks, in order to obtain more adhesion. The point of attachment of the pole to the main axle should be as close as possible to the beam, without causing the horse on the off side to walk in the standing grass. There is usually about 18 in. from the center of the pole to the first finger upon the beam; but when a mower is used for reaping, as is sometimes the case, the pole is placed about 2 ft. 4 in. from the first finger, otherwise the off side whippletree breaks down the standing corn, while in the case of short grass it passes over.

The speed of the knife, without being excessive, should be sufficiently quick to maintain a clean sweet cut, and to clear itself from all loose dirt. The throw of the knife in mowing is about 3 in., and the distance between each pair of fingers is the same; each section, therefore, travels from the center of one finger to the center of the next, and back again. But in reaping machines each section travels from the center of one finger to the center of the finger on either side, having thus a "double row" of 6 in. The number of revolutions of the crank-wheel in a mowing machine is $2\frac{1}{2}$ to $2\frac{3}{4}$ for each foot advance of the machine, while in a reaper, owing to the double throw, the number is generally from $1\frac{1}{2}$ to 2 per foot.

Some mowing machines are designed with the cutter-bar lying to the rear of the main axle, the other principles of construction being much the same. With this plan difficulty is experienced when backing the machine, the tendency being to force the beam into the ground; also it is difficult for the driver to keep his attention fixed upon both the cutter-bar and the horses. This plan, however, is almost imperative when the machine is also to be used as a side-delivery self-raking reaper, as will be shown presently.

We will now pass on to the second division, namely, machines designed for harvesting corn, or reaping machines.

These may be subdivided into three types:

(1.) Those which deliver the cut crop at the back of the beam, as in a mower; or back-delivery reapers.

(2.) Those which are provided with a platform at the back of the beam, on which the cut crop falls, and is then raked off to the side of the machine by revolving rakes; or side-delivery rakes.

(3.) Those which cut the crop, deliver it into suitable receptacles, bind it into sheaves, and deposit them on the ground; or automatic binders.

Back-Delivery Reapers.—A reaper of this first division is a much more simple piece of mechanism to deal with than a mower, because there are not the same difficulties to contend with in the case of dry crops or corn as of green crops or grasses. The speeds are consequently slower, the working parts fewer, and the strains not so severe.

The simplest of all reapers is the manual back delivery, in which a man, who has a seat provided for him on the body of the machine, uses a short hand-rake and so collects the standing corn into the knife, where it is cut, and falls upon a slatted platform which is hinged to the cutter-bar. This platform is held in an inclined position till sufficient corn is cut and collected to form a sheaf, when the man, by means of a foot-lever, allows the platform to drop upon the ground; the sheaf is then deposited, the stubble assisting the raking off of the sheaf by projecting up between the slats of the platform, and thus acting like a comb. As soon as the sheaf is raked off, the platform is raised again, and a fresh sheaf collected.

This form of platform may be attached to the beam of an ordinary two-wheeled mowing machine, and an extra seat fixed upon the main frame for the raker; this, with a special off side shoe, which will be described immediately, constitutes a combined mower and manual reaper. The speed of the knife either remains the same for both operations, or it can be altered by substituting a larger first-motion pinion, or by other equivalent means. The off-side shoe of a reaping machine differs in size and construction from that employed for mowing, because of the height of the corn and the difficulty in separating it. It carries dividing irons, which project about 15 in. to 18 in. into the crop, and thrust on one side the standing corn so as to admit of a clear passage for the shoe and wheel.

In the automatic back-delivery reaper, the place of the raker is taken by a revolving reel, which is driven by suitable chain gearing from the axle of the machine. This reel has three blades, which collect the corn on the platform, and one rake, which rakes the sheaf off, the platform receiving its dropping movement by means of a cam and rod. The reaper pure and simple, that is, when intended to be employed only as a reaper, is carried on one broad main wheel at the near-side, and supported by a small wheel fixed to the off-side shoe. The frame and gearing are carried by the main axle, and the beam is bolted on to part of the main frame. The cutting parts, or fingers and knife, do not differ materially from those described in the mower, with this slight exception, that where the crops are very dry, as on some parts of the Continent and in America, the edge of the section is serrated, thereby causing a sawing action rather than a cutting one. The first motion is usually taken from a ring of teeth cast on, or attached to, the inside periphery of the traveling wheel; but, in some cases, from a spur wheel fixed to the main axle, as in the second class of mowers.

In an automatic back-delivery reaper, as in a manual machine, it is necessary to tie up and remove the sheaves, before being able to go round the field a second time, and this objection has led to the designing of the side-delivery machine.

[To be continued.]

SADDLE HORSES.

IT is indeed a pleasure to notice that our people are, by degrees, cultivating a desire for that most invigorating and health-giving of all out door enjoyments—equestrianism. To ride well is an accomplishment of which any lady or gentleman may well be proud, though there are few in our section of the country who are masters of the art in all its various details. Mounted on a high-spirited and well-bred horse, upon which the rider is at perfect ease, a graceful figure shows to the best advantage, while it imparts that healthful, vigorous feeling which those who have never experienced it have but a faint conception of. Who can say that a beautiful woman ever presents so attractive and picturesque an appearance as when mounted on a noble horse? There is that beautiful color to her cheek as her steed gallops along with his elastic stride which the butterfly belles of the ballroom may well envy her. The saddle is the doctor's enemy; it is the cure for more disorders which suffering nature is heir to than most people are aware of; therefore the more that take this best of daily exercise, the fewer dyspeptics and subjects for gout and other ailments shall we have in our midst. But to enjoy riding it is essential to have a horse fitted for the purpose. some people think that if a horse will allow you to mount him, and he can be put into a smart gallop, he is a saddle horse, but this is a great mistake. Such people have not been educated up to what really goes to make up a perfect saddle horse in all the fine points, in appearance, disposition, weight-carrying capacity, and, above all, regulation and ease of gait.

It has hitherto been a very difficult matter to obtain, in this part of the country, horses which are adapted for this use, and even now we are obliged to go to Kentucky and the Southern States to find them. In Kentucky, Tennessee, and Virginia, we probably see the art of horsemanship. both in relation to horse and rider, carried to a higher standard than in any other part of the world, not even excepting England. The Kentucky saddle horse is a model for an artist; his gait and temper are perfection itself; a mount of velvet, obedient to the weight of a feather; indeed possessing. as he frequently does, a fiery and nervous temperament, yet so perfectly is he trained that it takes but the slightest pressure of the rider's knee or the inclination of his body to change him from one gait to another, or the smallest touch of a finger to control him. In gaits he has a variety: a rapid walk, fox-trot, rack, trot, lope and run—changing at the pleasure of the rider. These horses are thoroughly bitted when young and taught to carry a high and stylish head.

Saddle horses are not bred wholly from thoroughbred running stock, though many of them are nearly thoroughbred; nor is the turf a proper school from whence to select scholars to educate for the purpose; the gallop of the race horse is by no means the saddle gait. Some racers turn out to be good saddle horses, but not often. Saddle stock may be rather regarded in a measure as a breed by itself, composed largely of the best blood, from whence these models obtain that elegance of form and finish for which they are so noticeable. A great deal of the saddle stock in Kentucky is descended from the famous four-mile race horse, Denmark, foaled in 1839, a son of imported Hedgeford. Denmark was himself a natural saddle horse, as, indeed, were most of his stock. They possessed great style and a fine temper; these qualities they transmitted to their progeny to a remarkable degree and the family display it to this day. The Copperbottoms, Bald Stockings, and Tom Hals were also favorite saddle strains among the thoroughbreds. The rule is to select the dam on account of her gaits, and to breed her to a thoroughbred horse of docile disposition. This insures a colt with the staying qualities and fleetness of the racer, combined with the fine walking, racking, and pacing gaits of the dam. Training completes the work, and the saddle gaits are soon developed to perfection.

I see no reason why some of our stock-breeders here, in New England, do not make a start, and breed some colts fitted for the saddle. This class of horses are bringing large prices to-day, and there is a splendid field for a profitable venture in raising such.—*Alexander, in N. E. Farmer.*

TO KEEP VERY SHADED PLACES GREEN.

ESPECIALLY in the front yards of dwellings, both in town and country, which are much shaded, we often see the ground completely bare, not a living thing being perceptible. Sometimes there are many nearly nude, straggling limbs lying upon the ground or very near it, which are unsightly and every way worthless, that ought to be cut away. This would give room for the growing there of some plant or vine that would be adapted to it, and which would not only recover the naked spot and make it a "living-green," but would be adding very much to the general appearance of the premises. The best vine for this purpose is the periwinkle. It will grow almost anywhere in the shade if the proper attention is given to it, but not otherwise. It is a beautiful vine and will densely cover the ground, producing nearly the whole season a very pretty blue flower. Weeds, however, are its deadly enemies. It cannot fight them. Steadily they will encroach until they drive away our favorite and occupy the field of battle. A little help now and then, however, will defeat the common enemy, and allow us to enjoy the cool-looking, popular evergreen for many years without renewal.—*Germantown Telegraph.*

ENSILAGE.

MANY of the arguments of those who thus far favor ensilage are partial and one-sided. They leave out important factors from their results. Everything in favor of ensilage is stated at its highest, and all in favor of hay at its lowest. We have ensilage put up at 40 cents per ton (Dr. Bailey—page 25), and timothy hay rated at $20 per ton. We have a fearfully exhaustive crop (corn fodder), which requires immense manuring, and even then will, in a few years, ruin the texture of a clay soil, compared with a recuperative crop like clover, as if both were alike exhaustive. We have it "not at all difficult (page 27) to raise 40 to 75 tons per acre, *upon an average*, on good corn land," and "two tons of it is worth more than a ton of best timothy" (page 99), while the average maximum of timothy is put at two tons per acre! But our writers fail to notice that if the feeding value of the acre of corn, as ensilage, is 20 to 37½ as great as that of the acre of timothy (as proved ?), then the corn has taken from 20 to 37½ times as much *out of the acre* of valuable elements to be restored.

This illustrates the extravagant and one-sided claims made. Nor do the writers improve in this respect as time advances. On page 339, May 26, Dr. Bailey sets out to prove the superiority of ensilage over hay in results produced in feeding, or to show how much you can make with ensilage fed to a grade Hereford heifer two years old, less eight days. He rates the heifer at $18, or a shade over 2½ cents per pound live weight at the start, October 12, and at $57.75, or 5¼ cents (live weight) at the close, March 28. For grain he feeds 501 pounds cotton-seed meal, at $25 per ton, $6.51 (?), and 501 pounds wheat-bran, at $15 per ton, $3.51 (?). (The first should, of course, be $6.26, and the second $3.76.) The manure of the first he counts worth $6.98, 47 cents more than the meal cost (by his figures), and the manure on the second $3.65, or 14 cents more than the bran cost! Total gain on meal and bran by turning them into manure, 61 cents! But in the *hay* experiment, next page, he figures that he *loses* $12.26 on the corn meal fed, and *loses* 9 cents on the bran fed. Why does he lose now, when he gained before on bran? Why does he substitute *corn* meal here, on which he must lose $12.26, for cotton-seed meal, on which he could *make;* which is worth more after feeding than before?

Now I rise to remark, first, that a man who blunders in the simplest computations should not teach book keeping. Second, that if the manure is worth more than the meal bran that makes it, and thrifty grade heifers can be bought and then sold at the figures named, the average Ohio farmer could make money by feeding even *hay* and bran and cotton-seed meal. Third, if the doctor will furnish thrifty Hereford heifers of the age, weight, and condition, and at the price named, 2½ cents per pound live weight, I will take 50 car lots next October, and he can draw on me at sight. Fourth, if an Ohio man were arguing in favor of hay, and arguing *hard*, he wouldn't put it at $20 per ton and ensilage at $2, or lowest possible cost of production, but would put the hay thus: Interest on one acre land, $60, at five per cent. $3; cost of cutting and curing 3 tons hay, $3; total cost of 3 tons timothy hay, $6; total cost per ton, $2. The land is worth that, and will produce that, and the hay can be cut for that, if you figure as they do on ensilage. Figures can be made to lie the worst of anything on earth. Grant me my premises and I will prove anything.

I remark, lastly, that when the doctor quotes from the present writer to prove small gross annual receipts per cow on the Western Reserve, he quotes from an article written three years ago when cheese and butter touched bottom prices, and giving factory receipts, not total (as I remember), and showing that *exclusive* dairying under the factory system was financial ruin, and urging a mixed agriculture with wheat and clover as important crops; the very system now largely pursued.

The fact is that in Ohio and the West (except in the dairy regions) we already have far more coarse feed than we can use. Farm animals in the grain regions are wintered mostly on straw and cornstalks, with a little hay and grain, the hay being fed to work horses fall and spring, and the second crop of clover being cut for seed, and thousands of acres of stalks waste unfed, and thousands of tons of straw are burned or rot down, not even being used for bedding, or to be "worried down" into manure by animals in a barnyard. That this is wise I do not say. But while it is true, the days of ensilage seem distant. Of the labor of handling 80 per cent. or more of water with every 20 per cent. of feed, I do not care to think or speak. Present prices of western land, labor, and products do not seem to warrant it.

Can it be assumed that the milk, beef, and muscle made from ensilage are of as good quality as those made from good hay? October milk, when the pastures are not so rank and succulent as in June, is almost twice as rich in butter as June milk, and the milk from nice, green-cut clover hay, with a very little corn or oil meal, is richer yet. Doubtless the *flow* of milk from ensilage is greater than from hay. Doubtless, too, the quality is poorer. Milk can be watered through the cows' stomachs as well as in the can. So in regard to beef. "Grass beef" cannot at all compare in the Chicago yards with Gillette's corn-fed bullocks, so much admired by Dr. Bailey. Even in summer 800 bullocks of a ton weight each are confined by Mr. Gillette in a pasture of 140 acres—less than one-half acre each. They eat little of the knee-high grass, but *much* of the corn from the will-filled "corn tables." *Corn* makes "Liverpool steers." Grass and ensilage will not do it. And in regard to *muscle*, the case is still worse for ensilage. You cannot even sell new hay or new oats to a livery stable keeper. They do not want to "soften down" their horses. What would they say to grass or ensilage?—*W. I. Chamberlain, Columbus, O., in Country Gentleman.*

JOTTINGS ABOUT SNAKES.

WHAT is the use of a snake's long forked tongue? They do not catch insects as some lizards and batrachians do; they do not lap water, and we all know now how absurd was our forefathers' notion of the reptile *licking* its prey all over to moisten it before swallowing it. The moisture on the biggest snake's tongue would hardly wet a fly, for it scarcely comes in contact with the cavity of the mouth at all, but is protruded from a sheath which lies between and above the salivary glands, and below the mucous membrane, which is reflected or doubled back over it. A serpent darts out its tongue whenever it is excited from any cause—anger, fright, hunger—and thus we see it flickering over the body of the animal which it is going to devour, while searching for the head (which is almost invariably taken in first); hence arose the mistake about the preparatory moistening. In the mouth the food becomes soaked with an abundant saliva, but the tongue is retracted during the whole process of deglutition.

I have been watching an anaconda this morning, whom I have taken in to board and lodge for the voyage, and whose box cuts out so large a slice from my already overburdened cabin that I have to sit on it instead of a chair, for which there is no room left. Indeed, the anaconda is much better off than I am in point of spaciousness, though I admit I shouldn't relish being liable to be turned up on end at any moment, as I am obliged to serve him whenever I want to open my cabin door. He is a nice specimen, some ten feet long, healthy, took two fowls a fortnight ago, enjoys his bath, and is getting fairly quiet. I don't trust him much as yet, but I have had him out two or three times and played with him until he began to get fidgety. He does not belong to me, and is destined at present, I believe, by his owner (who is horribly afraid of him) for the Jardin des Plantes in Paris; but I hope that before the end of the voyage he will see the error of such a course and insist upon my accepting it, which I should certainly, though reluctantly, do. If he does not, may the pangs of remorse get hold upon him when he sees this article! Well, I gave this snake a fowl this morning, which, however, he has not taken yet; but I think he will before long, as he takes a decided interest in it, manifested by his watching the bird's every movement and constantly shooting out his black bifid tongue. "Lolling," I should say, rather than shooting, for an anaconda for some reason or other is much lazier in its maneuvers with that appendage than other serpents. The hen, on the other hand, takes no interest in anything beyond the handful of maize I have thrown in, and devotes herself most energetically to what is probably her last dinner; but every time the quivering black line catches her eye she makes a determined dab at it—two or three in quick succession, sometimes till I begin to fear lest she should hurt the snake. Now, why does she do that? Certainly from no animosity toward the anaconda, whom she does not attempt to molest otherwise, and in whose presence she cannot have the slightest consciousness of danger. My own idea is that she mistakes the tongue for a wriggling worm and pecks at it accordingly; and that it is to attract the animals which form their prey that snakes are furnished with this peculiar organ. I have seen a frog snap much in the same way at a moccasin snake. If we take these reptiles as a body, living in their native woods or jungles, I imagine we should find the bulk of their food to consist of birds for what we may term the hard feeders, and frogs and lizards for the soft feeders. I use the words simply to illustrate the distinction for a moment, in the same sense that one speaks of seed birds and fruit birds.

Although the constrictors and others do not refuse rats, rabbits, guinea-pigs, goats, and other animals—and, indeed, no doubt, devour many, even in their wild state—yet it must necessarily be from the feathered tribe that the great majority of their meals is supplied, when one takes into consideration the enormous preponderance in number of birds over mammals in forests and swamps teeming with life, and the fact that a snake cannot be said to pursue its victim. It lies in wait concealed or unperceived until the prey comes within striking distance, and twenty birds might pitch within that radius before an animal ran across it; they climb trees, too, and kill roosting birds at night (not to mention robbing nests), when four-footed beasts are not so readily caught napping. Most birds are more or less insectivorous, so are lizards and frogs, and it seems to me that they may be supposed to be attracted by the rapid quiver of the serpent's tongue within its reach. Fish, again, might be lured to the surface by the action of such a bright flickering flash at the top of the water. I have seen snakes hanging motionless from boughs and creepers over the rivers of Central America, ready to dart when a fish appeared. All frog-eating reptiles will take fish. I was dining with a clergyman in the weald of Kent one summer evening several years ago, when one of his little girls came running in at the window to say there was a snake in the pond. "An eel, you mean," said her papa. But Effie was not to be shaken in her theory, and was sure she saw a great long thing go down the path into the water. So to satisfy her, we strolled out after dinner. "Look!" cried Effie; and sure enough there was a common grass snake making its way up the opposite bank with the tail of a half-swallowed fish sticking out of its jaws. A laborer came running up, splashed through the water, and killed it with a stick before we could get round, and my friend had it stuffed with the fish (a perch, I think) *in situ*.

I was walking up the track some time back at Port Simon, Costa Rica, and just ahead of me I saw a small snake flit away behind a stone. Though quite close to it, I had not time to observe of what kind it was, not even to note its color or a single detail beyond its size; indeed, if it had not taken alarm at my approach, I might very likely have passed on without seeing it at all, so closely do these creatures simulate in form and hue the surrounding objects. So I halted instanter, and stood perfectly still, while I deliberated how I might best effect its capture, for though the piece of rock behind which it was hiding was isolated, it was so by only a couple of feet from the grass and jungle which bordered the narrow track. While I stood deliberating thus the snake's head came cautiously round the rock again, its tongue excitedly gleaming and twinkling in the hot sunlight; and as we both remained so for some seconds a glorious little crimson tanager flew down on a bush situated about midway between us, and commenced to eat something. Suddenly, I suppose, it caught sight of the reptile's tongue, for it hopped down close beside its head. I have no doubt it would have been seized or struck the next moment, but I made an incautious movement, and bird and snake were gone.

It would be interesting to know why some have red tongues and others black. Here beside me in a glass case are two little snakes, both belonging to the same genus (*Tropidonotus*), a seven-banded (*T. leberis*), and a moccasin (*T. fasciatus*), both hailing from the United States, and alike in their habits and choice of food; yet it is a case of *rouge et noir* with their lingual appendages. A curious thing occurred with these two reptiles at the beginning of the voyage. They had each taken some half-dozen frogs the day before sailing, and were, in fact, gorged and bloated like sausages. We got bad weather outside, and a heavy sea, in consequence of which they actually became seasick, and at the end of twenty-four hours were as lean as ribbons. It must not be inferred, however, that the mere movement of the ship effected this unpleasant result in the usual way; the fact was, I carefully "chocked off" their box in anticipation of the rolling, but forgot that the poor little snakes inside had no such stay, so they slid from end to end of their cage at every lurch of the vessel until I discovered the state of affairs. Quite enough to make them sick. They are growing rapidly, and have appetites beyond their food supply just now, but they don't get very tame; the seven-banded in particular bites whenever he is touched.

Which is the best way to tame an animal and cause it to become attached to you? By feeding it? A very potent means, doubtless; but if I mistake not there is an agent more potent still. When I was at the Zoological Gardens in London a few months ago, Mr. Bartlett, the well-known superintendent, very kindly accompanied me round the various houses and inclosures, and I was much amused and delighted to see how readily every animal came toward him. Not only monkeys and elephants and bears, and ostriches and such-like, who are always ready to display "cupboard love" toward everybody, and to whom the mere sight of a paper bag is a sufficient introduction at any time, but dignified and reserved creatures, which would scorn the attentions of an F.Z.S., not to mention the casual shillingsworth—big dozing cats, meditative swine, exclusive beasts with horns, bowing giraffes, trotty little furred things on short legs, all came to hand; and not with any paper-bag rush or expectancy of any kind, no more than there is in a dog's expression of pleasure when his master pats him. Now, Mr. Bartlett sees them every day in making his tour of inspection, but, of course, never feeds them; and on my giving vent to surprise that they should all know him so well, he told me, *apropos* thereto, the following anecdote, which I hope he will pardon me for reproducing here, as it appears to me to be very illustrative and instructive.

Among the *employés* at the gardens he once had a night-watchman, who, being a sober man and very attentive to his duties, was promoted to the office of keeper. Here, too, he behaved as well as any one could desire; fed his charges regularly, kept them clean, was intelligently observant of their wants and habits, and did everything in his power to promote their comfort. Yet, singular to say, the animals never became attached to him, but, on the contrary, often conceived the most violent dislike for him. It is very essential, as may be imagined, to the health and well-being of beasts in captivity that they should be kept free from all worry or vexation, so Mr. Bartlett, knowing that most unaccountable and capricious prejudices against particular individuals sometimes arise among them, moved him to another house—moved him to two or three in succession, in fact, but always with the same result. The man himself freely admitted that such was the case, and tried to remedy it, but without avail.

"I don't know how it is, sir!" he said. "I wish I did. I'm sure I never teased nor hurt that hippopotamus in my life, and I've done all I can for her, but she's always going for me, and if she could get at me she'd kill me!" and, in sooth, the lady in question, in whose boudoir the unhappy keeper was stationed at the time, gave ample demonstration of her willingness to reduce him to a fine state of subdivision at the earliest opportunity. Still, Mr. Bartlett argued, there must be a cause, and forthwith set himself to watch, making, at length, this grand discovery—*the man never talked to the animals!* That was the secret of the whole trouble, and he remonstrated with him at once. "Talk to them, sir! But I don't know what to say to them." It is needless to observe that after that confession the keeper's term of office was of short duration. And, depend upon it, the human voice, personally addressed to an animal, has far more to do with gaining first its confidence and afterward its affection than all the feeding in the world. Mr. Bartlett has always a friendly word or gesture for each as he passes on, and they, in return, have one for him, according to their different modes of expressing it. Look at a dog. Which does he love the better, the servant who feeds him or the master who talks to him and takes him for a walk? It must be remembered that brutes bite or inflict other injury in *fear* from a real or fancied necessity for self-defense, and when we speak of their being tame we imply that we have taught them that there is no occasion for the use of their weapons, and have allayed their nervousness; in other words, when they trust us we can trust them. Caressing and feeding will go a long way toward effecting this, but talking—*friendly converse*—will bring about the result much quicker. On the other hand, it is easy to suppose that the constant spectacle at all seasons of a silent, staring man must be irritating to an animal—say a hippopotamus of delicate susceptibilities—who might have derived great comfort from human speech. When François Lecomte, the first keeper of the sea-lions, was alive, I used often to see him, early on summer mornings, carpentering or gardening about their inclosure, chatting all the while to the female who would be on the path beside him taking a quiet interest in all he said and did; and I myself once established such a perfect companionship with a cat that I half thought sometimes he was going to pat me.—*Arthur Stradling, in Land and Water.*

FOSSIL SAIGA-ANTELOPES.

IN the *Comptes Rendus de l'Academie des Sciences* of the year 1864, we find it remarked, by the renowned French scientist, Edouard Lartet, that the remains of the Saiga-Antelope are to be found in the quaternary deposits, and on account of the fact that he found only the horns of these animals, he supposed that they had never lived in France, but that the horns had been carried thither from the Steppes of Eastern Europe, as an article of commerce, to the ancient cave-inhabitants of that country.

At present this view can no longer be maintained. Albert Gaudry, Professor of Paleontology at the museum of Natural History, Paris, during a recent excursion to Angoumois and Perigord, found numerous fossil remains of Saiga-Antelopes contained in several private collections, and he found not only the skulls, but also parts of the extremities.

The best specimens were in the collection of Mr. Fermond, at La Rochefoucauld, and in that of Mr. de Maret, at Rochebertier. These specimens were discovered in some grottos near the shore of the Tardoire, a tributary of the Charente.

Prof. Gaudry has given very explicit accounts of these specimens, and described especially those contained in the collection of Mr. de Maret. This description is accompanied by splendid illustrations, and furnishes excellent material for the study of remains of the Saiga-Antelope.

It is probable that this animal has lived in other parts of Central Europe, and that many fossil remains, which have heretofore been taken for bones of goats, or even deer, are really parts of the Saiga-Antelope.

The fact this animal, which to-day is found only in the Steppes of Eastern Europe and Siberia, existed in France at so early a period, proves that it lived during the quaternary period in the western part of Europe, and this fact is another evidence for the hypothesis that during a certain period middle Europe bore the character of a large steppe.

NATURAL HISTORY OF BUTTERFLIES.

CARL VILLARET, the German entomologist, has recently published a work which may be considered one of the most valuable books on entomology, on account of the amount of information and new data it contains. On the first page is mentioned a fact which is but little known, viz.: that butterflies exist which produce living caterpillars instead of eggs. A very interesting chapter is dedicated to difference of sex existing already in the eggs of butterflies. Among other proofs for this difference he mentions the so-called parthenogenetic propagation. Some eggs remain unfructified, and the caterpillars born from these eggs propagate their race by female descendants only; for example, the so-called Psychides—*Fumea helix, Solenobia, Triquetrella*, and *S. lichenella*. The opinion that *Psyche stettinensis* possesses the capability of fructification while still a coccon, Mr. Villaret declares to be erroneous.

This error was the effect of mistaking the female caterpillar, which, in its shrunken form, resembles a cocoon, for a genuine cocoon; besides this, the female caterpillar, after the fructification, returns again to the cocoon shell.

Not all unfructified eggs produce butterflies of but one sex; some produce male as well as female.

Another remarkable circumstance is the fact that caterpillars and butterflies are two perfectly distinct beings, with separate organs, peculiar habits, special will, etc. Many of these caterpillars have social habits, such as three kinds of the European army worm—*Bombyx processionea, Pinivora*, and *Polyocampa;* the former live in a common nest, which they leave in the morning in order to procure food, and return to it in the evening. They march following a single leader, first, by twos, the heads of one pair always closely touching the tails of the others; then by threes, in several lines, and finally by fours, fives, sixes, or even more in the same manner and exactly in the direction of the movements of the leader. If the leader meets with some accident, another caterpillar promptly takes its place.

The caterpillars, *B. pinivora*, march in single file. The species, *Telemachus—Morpho metellus* of Surinam—leave their abode every morning at about 8 o'clock, when the dew has evaporated, march to the neighboring leaves to feed, and regularly return in half an hour.

The dwellings of some caterpillars are also very curious. The species, *Tinea rastella*, lives in the horns of the African buffalo, another one in those of the Kudu antelope, and another upon a certain species of monkey, Ai, of Guiana; still another like the moths—*Tinea, Pellionella, Tapezella*, and *Crinella*—in fur or woolen clothing, and others again in birds' nests, feathers, etc. Some caterpillars are able to produce sounds. Certain species are sensitive to climatic changes. *Papilio bronica* lives in Sicily when a caterpillar; in Germany it can only exist while a coccon; *Bombyx dispar* lives in England when a caterpillar, but can only exist in Germany while an egg. There are species of caterpillars living in the water; *Bombyx labulbeni*, which often eats and sleeps in the water, coming to the surface to spin itself in. Many caterpillars feed only during the night—*Papilio sophorœ*, and *P. Corydon*.

The manner in which the various butterflies break through the shell of the cocoon is very interesting. *Bombyx paphia* spurts a drop of liquid from its mouth, which softens the upper portion of the cocoon-shell; *B. vinula* produces the same effect upon its pergament-like cocoon by a drop of acid, and others pierce the shell by protuberances with which their foreheads are furnished. There are other chapters of this work which are dedicated to the variations, and which contain an abundance of information.

LAND SNAILS.

MR. PRINCIPAL J. W. DAWSON, LL.D., F.R.S., offered to the American Association a "Revision of the Palæozoic Land Snails, with Descriptions of New Species." The author noticed all the known Palæozoic species of land snails, six in number, two of which were described for the first time. Five of the species occur in the Carboniferous and one in the Devonian. Four of the species belong to the different subdivisions of the old genus *pupa;* two are small helicoid shells. They constitute a very isolated group, as no land snails are found in any older formation, and none occur in newer formations as far up as the eocene tertiary. They are also remarkable for their close resemblance to species of land shells still living. All the species as yet known occur in America, one Erian or Devonian species having been found at St. John, New Brunswick, three of the Carboniferous species in the coal field of Nova Scotia, and the remaining two in Illinois. They have been found in

beds of shale holding fruit plants or apricated with beds of coal, and also in the interior of erect trees, which had become hollow through decay before being fossilized.

DISINFECTION BY NITROUS OXIDES.

THE removal and destruction of the materials in privies in large cities has always been considered as a problem more and more difficult of solution in proportion to the increase of population. This question has become one of almost vital importance at Paris still more than anywhere else, by reason of the accumulation of the inhabitants within a more circumscribed area than in any other large city of Europe. It is scarcely necessary to go back more than about fifty years to find, in the majority of Parisian houses, a pit dug in the earth, polluting all the wells, as also the subsoil, and making a residence in the city unhealthy.

This state of things has been remedied by successive steps, and a great progress was effected when each householder was compelled to construct a perfectly tight privy vault. Along with a better knowledge of the hygiene of cities there followed improvements, either in the mode of removal or in the disinfection of the fecal matters, or even in the aeration of the vaults by the addition of a ventilating pipe. However, toward the year 1860, it had already occurred to the minds of eminent men that a much more efficacious means would be that of leading the privy matters into the large sewers which had been built during the construction of the great works at Paris; and this project was put to the test along about the year 1868. Here was apparently a complete solution of the matter - a large profit for the city, and cleanliness for the humblest dwellings through the constant supply of water on every story. But practice demonstrated that the question was not yet solved. It was soon found that, in fact, the matters were merely being diluted in order to carry them off a little further, but it became necessary to stop leading them into the Seine, however great the volume of water with which they were mixed. Without going further into history, we may state that these facts have given rise to two schools, so to speak. One of these desires to see the object effected by chemical and mechanical agents, while the other wishes to have the sewers used, along with a larger addition of water, and air filtration over very extended permeable surfaces. The first school urges, as advantages, the relatively low cost of the removal and the preservation of the material for fertilizers, so valuable to agriculture; but the methods it suggests demand numerous improvements to be made in the transformation of the extracted matters, and in the disinfection of the gases passing through the 80,000 ventilating pipes of the city houses, or through the chimneys of the works for treating the organic matter.

The second school recommends processes the employment of which would necessitate an enormous expense and be accompanied by an absolute loss of the fertilizing materials. It is true that the drainage in this case may be done with extreme facility, but it must be admitted that the method is only a way of getting rid of one's offal by spreading it among his neighbors. As for infection, that is the same in both systems. In the latter it proceeds from the mouths of the sewers, and in the former, from the tops of the houses, through the ventilating pipes.

This question of infection is now occupying the thoughts of everybody, and for this reason we call attention to a newly-proposed way of obviating it. Messrs. Girard and Pabst have found that by putting privy gases, all malodorous gases, all those produced by fermentation or by heating or calcining organic matters, in contact with sulphuric acid containing a proportion of crystals from leaden chambers (sulphate of nitrosyle), they are decomposed by the nitrous oxides which are set free by the action of the aqueous vapor that they contain.

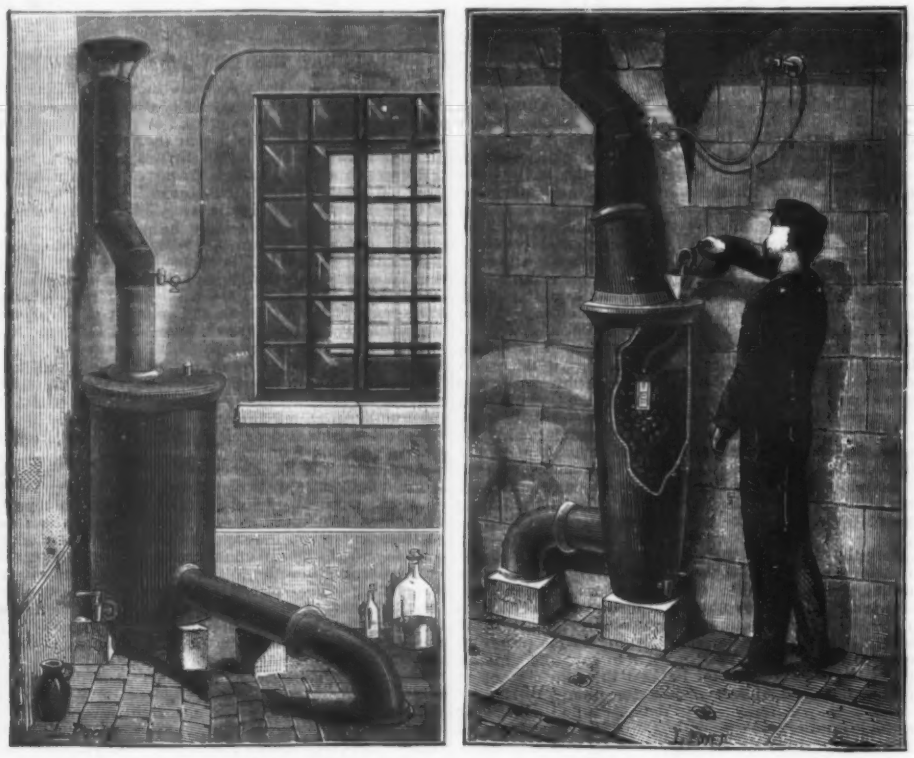
Mr. H. Suillot, who is making an application of the process, has obtained, from the "Public Assistance" of Paris, authority to place two apparatus of his invention over two vaults of the Hôpital de la Pitié, the disinfection of which it has never been possible to effect. This application will prove the possibility of disinfecting all ventilating pipes, the air of sewers, and the gases produced in the treatment of fecal matters, the calcination of bones, the melting of fats in soap and candle factories, etc.

By this process, such odors will not only no longer exist, but all germs will be destroyed, and we shall consider that a great stride has been taken in the question under consideration.

We give herewith, from *La Nature*, figures of two of the apparatus which have been placed in the hospital La Pitié. The gases from the vault are drawn through the base of the ventilating pipe into an earthen cylinder, about four feet in height, filled with pieces of coke saturated with nitrous sulphuric acid, which collects in the lower part of the apparatus under the gas inlet. It is readily perceived that the aqueous vapor which is always contained in the air and gases of these vaults, in condensing on the coke of the apparatus, will keep setting free the nitrous oxides contained in the nitrous sulphuric acid, and that the latter will then destroy the malodorous and deleterious gases such as sulphureted hydrogen. The draught of the ventilating pipe, which is more or less regular according to the pressure of the barometer, is aided in these apparatus by means of a current produced by a gas flame.

The apparatus shown in Fig. 2 is represented open in order to exhibit the arrangement of the column of coke and the small porous vessel into which is poured the acid through the funnel on the outside. The gas burners designed for creating a draught are to be seen in both apparatus.

The two privy vaults of the hospital, which formerly diffused throughout the rooms noxious odors which it was impossible to get rid of, were, by the use of the apparatus, at once purified, to the great satisfaction of the hospital staff. Nor is this all. On the day that the vaults were to be emptied it was found dangerous, because of the accumulation of noxious gases, to remove the covering stones; but through the effect of the ventilation here described the danger was removed, the noxious gases being drawn off by the strong draught in the ventilating pipe, so that the vaults could be emptied without danger to the workmen and without the escape of those gases which tarnish all the copper, gildings, silver, etc., in houses, and give out odors that every Parisian has become familiar with.



APPARATUS FOR DISINFECTING VAULTS.

TANNING.

By K. SADLOW.

PUTZ has patented a mode of tanning skins, which consists in dissolving blood, fibrin, gluten, animal fiber, hairs, wool refuse, horn, claws, feathers, etc., in soda lye, mixing the concentrated solution with fat (5–10 per cent.), and precipitating the mixture with sulphate of aluminum. The skins having been treated with alum and salt, are tanned with the precipitate until completely saturated; they are then pressed strongly, oiled, dried, stretched, and curried. The tanning is said to be waterproof, and leather tanned in this manner possesses great softness and pliability. Eitner correctly calls this operation "alum-tanning," the albuminous precipitate with alumina injected into the skins serving merely as a "filling agent" to give the skins their requisite degree of fullness and a better cut, as mineral tannin is absorbed by the skins only in a limited measure.

The author discusses the difference between mineral leather and the so-called "oozed leather." The most important distinction between them is the behavior of both when treated with pure water. Oozed leather does not alter its physical conditions when soaked in water; it maintains its firmness and pliability, while mineral leather loses its original character and assumes the properties which raw skins possess. Other differences of minor importance exist between these leathers, such as the changes exhibited in the drying process, the absorption of tannin by the skins, etc., all tending to show the superiority which oozed leather has over mineral leather.

King has patented a process of tanning skins whereby the ordinary method is said to be facilitated very considerably. The author entertains some doubt as to the practicability of the process. Although he agrees in some measure with the active motion and the constant renewal of tannin, which appear to be the main features in the new process, he thinks that the great consumption of motive power and the constant and intimate contact of the tannin with the air, hinder the practical results which the method originally promised. —*Dingler.*

CANE SUGAR FROM MOLASSES.

By U. GAYON.

IT is found that pure *Mucor circinelloïdes* ferment only attacks the directly fermentable sugars, or glucoses, not affecting the saccharoses, and moreover that it is a more powerful ferment than the ordinary beer ferment, but unlike yeast, it cannot produce fermentation unless there is a sufficient supply of nourishment for its propagation. These facts will be of great service to the sugar industries, in that the cane sugar can now easily be obtained from the molasses as follows: the molasses should be diluted until the glucose is present to the amount of not more than 10 per cent., the glucose may then be fermented by means of *M. circ.*, which does not act on the saccharose, and the action is not retarded by even 30 per cent. of saccharose; the fermentation must be preceded by heating the molasses to boiling, and allowing it to cool in closed vessels; the most advantageous temperature is 35–40°; care must be taken that only the mucer ferment is present, but it may be used repeatedly for several operations.—*Bied. Centr.*

A CATALOGUE, containing brief notices of many important scientific papers heretofore published in the SUPPLEMENT, may be had gratis at this office

THE
Scientific American Supplement.
PUBLISHED WEEKLY.
Terms of Subscription, $5 a Year.

Sent by mail, postage prepaid, to subscribers in any part of the United States or Canada. Six dollars a year, sent, prepaid, to any foreign country.

All the back numbers of THE SUPPLEMENT, from the commencement, January 1, 1876, can be had. Price, 10 cents each.

All the back volumes of THE SUPPLEMENT can likewise be supplied. Two volumes are issued yearly. Price of each volume, $2.50, stitched in paper, or $3.50, bound in stiff covers.

COMBINED RATES.—One copy of SCIENTIFIC AMERICAN and one copy of SCIENTIFIC AMERICAN SUPPLEMENT, one year, postpaid, $7.00.

A liberal discount to booksellers, news agents, and canvassers.

MUNN & CO., Publishers,
37 Park Row, New York, N. Y.

TABLE OF CONTENTS.

PAGE

I. ENGINEERING AND MECHANICS.—H. M. S. Polyphemus. The torpedo ram for the British Navy. 3 figures. View of the Polyphemus. Bow view, showing hull below water line. Launch at Chatham Dockyard 4631
The Polyphemus. Construction.—Engines.—Armament, etc. 4635
The Canal System of New York. Samuel McElroy's paper before the Western Society of Engineers. Canal projections.—Engineering.—Original engineer corps.—Construction.—Dimensions.—Operations 4639
The Bollee Steam Carriage. A new carriage for common roads. 4 figures. Passenger carriage.—Traction carriage for freight 4638
Annular Wheels. Forms of epicycloidal and involute teeth for inside gear.—Failure of the odontograph to meet certain practical tests. By Prof. C. W. MACCORD. 6 figures. Annular wheels. Forms of epicycloidal and involute teeth 4634
The Old Aqueducts of Paris. 1 figure. Aqueduct of La Vanne over the Valley of the Bièvre, with remains of an old Roman aqueduct and the aqueduct of Marie de Medicis 4637
Farquhar's Filtering Apparatus. 8 figures. Sections to scale of various parts of Farquhar's apparatus 4637
Suggestions about Stuffing Cushions. 2 figures 4638
On Harvesting Machinery. By E. SANDERSON. Mowing machines.—Cutting apparatus.—General features of design.—Dark delivery reapers 4643

II. ELECTRICITY, LIGHT, HEAT, ETC.—Heat in Relation to Chemical Action. By HENRY ALLEN. Recent advances in thermo-chemistry.—M. Berthelot's calorimetric apparatus.—Principles of chemical mechanics.—Application of the principle of maximum work 4638
A Simple Equatorial. 1 figure 4640
Voss's Induction Electrical Machine. 1 figure. The Voss-Holtz Electric Machine 4641
The Pressure of Wind 4641
Hylozoic Materialism. By ROBERT LEWINS, M.D. 4641
Theory of Thermo-Electric Motive Forces. By M. PILLEUR 4642

III. HYGIENE AND MEDICINE.—The Chemical and Physical Effects of Fillings upon Teeth. By CHARLES MAYR.—The chemistry of albumen.—Chemical complexity of tooth substance.—Kinds of fillings.—Effects of fillings.—Mechanical effects.—Thermal effects.—Chemical effects.—Electrical effects.—Gold the worst filling in most cases 4643
Rheumatism. Dr. M. P. GREENWOOD 4643
Modification of Anæsthetic Methods 4644

IV. TECHNOLOGY AND CHEMISTRY.—Disinfection by Nitrous Oxides. 2 figures.—Apparatus for disinfecting vaults 4646
Tanning. By K. SADLOW.—Patented processes 4646
Cane Sugar from Molasses. By U. GAYON 4646

V. NATURAL HISTORY.—Jottings about Snakes. By ARTHUR STRADLING.—Use of the snake's forked tongue.—How to tame shy animals.—Taming influence of friendly speech 4645
Fossil Saiga Antelopes 4645
Natural History of Butterflies 4646
Land Snails.—Fossil species 4646

VI. AGRICULTURE, ETC.—Saddle Horses.—Special requirements and special breeding necessary 4644
To Keep Very Shaded Places Green 4644
Ensilage.—A caustic criticism of Dr. Bailey's claims 4644

PATENTS.

In connection with the **Scientific American,** Messrs. MUNN & Co. are Solicitors of American and Foreign Patents, have had 35 years' experience, and now have the largest establishment in the world. Patents are obtained on the best terms.

A special notice is made in the **Scientific American** of all Inventions patented through this Agency, with the name and residence of the Patentee. By the immense circulation thus given, public attention is directed to the merits of the new patent, and sales or introduction often easily effected.

Any person who has made a new discovery or invention can ascertain, free of charge, whether a patent can probably be obtained by writing to MUNN & Co.

We also send free our Hand Book about the Patent Laws, Patents, Caveats, Trade Marks, their costs, and how procured, with hints for procuring advances on inventions. Address

MUNN & CO., 37 Park Row, New York.
Branch Office, cor. F and 7th Sts., Washington, D. C.

PAGE
The Poly-
nch at
4631
te.... 4631
before
gineer-
-Oper-
4632
ronds. 4632
th for
netical
rheels.
4634
of La
an old
4637
cal of
4637
4638
ng ma-
—Black
4643
tion to
ices In
—Prin-
ple of
4638
4640
s-Holtz
4641
4641
4641
UH.... 4642
hysical
chem-
ance.—
hermal
rat fill-
4642
4643
4643
Nitrous
4646
4646
4646
RTHUR
me shy
4645
4645
4645
4646
rements
4644
4644
4644

MUNN & Co.
ears' experi-
Patents are
of all Inven-
dence of the
ention is di-
nction often
an ascertain,
by writing to
aws, Patents,
th hints for
rk.
gton, D. C.